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# THE FUTURE MANAGEMENT OF THE RADIO SPECTRUM

## CHAPTER 1:
## EXECUTIVE SUMMARY AND POINTS FOR COMMENT

1.1 The radio spectrum is a vital, but limited, natural resource. Demand for frequencies is outstripping the pace of technological change in expanding the boundaries of the 'usable' spectrum. The central thrust of this document is to seek the most effective ways of managing this scarce resource to the maximum economic benefit whilst safeguarding access for defence, emergency services and social use. Many success stories of the last decade, such as the explosive growth in the use of mobile telephones and the expansion of independent local and national radio broadcasting, have hinged upon timely access to spectrum. New developments, such as the use of radio for the 'last mile' to bypass conventional local telephone networks, the delivery of advanced data and multimedia services to mobile terminals and Microwave Video Distribution Systems (MVDS) to deliver a plethora of television services, are all contending for access to spectrum. These developments emphasise the crucial role of radio in facilitating economic growth. The key question is how to accommodate them.

1.2 This document describes how the radio spectrum is currently managed in the UK and outlines possible changes to meet future demands. The Government wants to ensure that scarcity of radio spectrum does not become a barrier to growth of radio-dependent services. Any measures taken to improve access to the spectrum should benefit both users and manufacturers of radio equipment, stimulate innovation, enhance competitiveness, open up larger markets and help increase competition.

1.3 The Government would welcome comments from present and potential radio users and other interested parties, including manufacturers, network operators and service providers, on the many issues raised here. Comments should be sent by 22 July 1994 to Laurence Green at the Radiocommunications Agency, PO Box 3989, London SE1 8YD.

### CURRENT MEANS OF MANAGING THE RADIO SPECTRUM

1.4 In recent years, the Radiocommunications Agency (RA), an Executive Agency of the Department of Trade and Industry, has taken a number of steps to widen the availability of the radio spectrum by, for example:

- organising sharing arrangements between major users and new market entrants;
- sharing out more widely certain large blocks of spectrum historically allocated for the exclusive use of certain large licensees;
- successfully encouraging the exploitation of frequencies above 30 GHz for fixed services;
- promoting the use of technology capable of increasing user access to and useful capacity in particular bands;
- enforcing loading criteria and withdrawing assignments when loading levels no longer justify them;
- initiating a series of independent Spectrum Reviews.

1.5 These measures, covered in *Chapter 4*, will continue. Comments are particularly requested on the following broad issues (paragraph references are in parentheses).

1) The current means used by the RA for managing the radio spectrum (4.25) and the overall quality of its activities.

2) Areas where there are shortcomings and room for improvement.

3) Suggestions for further specific actions (4.26).

## ORGANISATION OF SPECTRUM MANAGEMENT

1.6 Further changes which could be made within the existing legislative framework are covered in *Chapter 5*. These include tightening the machinery for planning within Government, a stronger industrial voice in the RA's advisory arrangements and more licence distribution performed by bodies outside Government. All these changes could have a positive impact on the effectiveness of spectrum use.

### Privatisation of spectrum assignment functions (5.11-13 and 7.19-27)

1.7 Chapter 7 considers the scope (after appropriate legislation) for the progressive contracting out of an increasing number of frequency planning and assignment tasks through setting up spectrum management organisations (SMOs), which would make assignments on a commercial basis. They would acquire management rights over blocks of spectrum by auction or other selection procedure. Private sector SMOs could be either user groups or commercial bodies. They would be well placed to monitor the loading of the frequencies they assigned, to arrange channel sharing and in other ways to improve the utilisation of the spectrum. Similar organisations are widespread in the USA.

1.8 If these private sector organisations multiplied, the RA's functions would be progressively cut back. In due course they could be confined to a core of functions which only Government can perform, such as representing the UK in international negotiations, regulating the operation of SMOs and ensuring compliance with licence and standards obligations. In this way much of the management of the spectrum would be progressively privatised (see also paragraph 1.21 below).

1.9 The Government would particularly welcome respondents' views on these questions.

4) Have the existing self-management organisations been successful in terms of maximising efficient spectrum use? (5.11-12)

5) Is there further scope for extending self-management arrangements to other user groups? (5.11-12)

6) Would there be benefits in introducing commercial SMOs and, as a result, securing the partial privatisation of the spectrum management process? (7.20-27)

7) What effect might they have on efficient spectrum use, eg by finding room for more assignments or by providing consultancy services leading to investment in the best system to meet users' needs? (7.24)

8) What, if any, problems might be associated with acquisition of management rights by these bodies?

### Advisory Committee (5.8-10)

1.10 The Stage II Spectrum Review Committee recommended that there should be an independent advisory committee on spectrum management issues, reporting directly to Ministers.

9) Is there a need for an independent advisory committee, separate from and additional to the periodic Spectrum Review committees and, if so, how might its effectiveness and independence be ensured?

### Access to Databases (5.26-27)

1.11 As the RA's information technology base improves, it may become possible to give greater user access to databases of frequency allocations and assignments held by the Agency, while preserving the privacy of individual information. This would enable spectrum users to have better information on which to base their own service plans.

10) Is more open access desirable? What kind of information would be of most interest to radio users?

## PRICING

1.12 With new legislation, changes could be introduced to the existing fees-setting regime. Under current legislation, the Government has little flexibility for using price as an instrument for achieving efficient spectrum use. Users paying a purely cost-based licence fee, at a generally low level, have little incentive to economise on their spectrum use or to shed spectrum surplus to their needs.

1.13 New pricing systems could encourage users to choose between different types of service operating in different bands of the spectrum and offering various degrees of spectrum efficiency or even to consider alternative means of communication. They could also give spectrum users an incentive to invest in technologically advanced equipment and techniques. These make maximum use of available spectrum and help increase the number of users able to occupy particular spectrum bands. The Government does not intend to use spectrum pricing as a means of taxation.

1.14 Possible models for introducing pricing systems based more closely than now on market pressures are described in Chapters 6 and 7. Any pricing system would have to give rights which lasted for a set period. This might be for far more than one year (the current renewal period). Respondents are asked to comment on the general question of whether price should have a place among the other means employed for managing the spectrum, and on the particular points highlighted below. There are two main options: administrative pricing and auctions.

### Administrative pricing (6.20-27)

1.15 The purpose of more flexible fees setting would be to increase radio users' awareness of the opportunity cost of spectrum use, encouraging them to apply for and retain only the spectrum they need. Charges could be built up from a number of separate elements based on any or all of various criteria such as:

- frequency band occupied;
- amount of spectrum used, in MHz;
- number of channels or links used;
- degree of loading;
- efficiency of equipment;
- transmitter power/coverage area;
- geographical location.

11) Would any of these bases for setting fees for spectrum used separately or in conjunction with others:

a) influence the type of radio service chosen by users?

b) influence whether they use radio or other means of communication?

c) encourage users to economise on their frequency requirements, releasing spectrum for other users?

d) encourage movement, within technical limitations, to higher or less congested bands?

e) benefit spectrum management in any other ways?

12) What would be the advantages and disadvantages, for existing users or for new users, of replacing the current fees-setting regime for licences with administrative pricing based on some or all of these criteria?

13) Would administrative pricing have any advantage over establishing market prices throug an auction system?

### A more radical approach

1.16 The second of the two methods for possi change to the pricing mechanism of the exis spectrum management system would involve creation of a system of tradeable property right spectrum. This would mean a change from the c rent legal basis of rights to spectrum use (licenc to operate radio transmission equipment, subjec to revocation by Ministers) to some kind of fixed-term spectrum access right.

### Auctions (7.39-58)

1.17 There are several ways of using auctions or other bidding processes to let the market decide who should have access to the spectrum.

Management rights could be auctioned to SMOs, which would manage the assignment and licensing processes in either the fixed link or private mobile radio bands on a commercial basis. Auctions could also be used by the RA for direct sale of spectrum rights to users. This process could aid selection from among several bidders competing for unoccupied spectrum when there is not room for all and when different bidders place a different value on it.

1.18 Chapter 7 outlines the potential benefits of spectrum auctions and the problems associated with them. New Zealand and Australia are ahead of the field in spectrum auctions: Annex A describes the spectrum management systems operating there and in some other countries.

1.19 The Government would welcome comments from respondents on the general question of the potential usefulness of bidding processes as a means of improving spectrum management and on the following issues.

14) The benefits and drawbacks of auctioning management rights to commercially-run SMOs (on a "wholesale" basis);

15) Direct auction of spectrum rights by the Government to users (on a "retail" basis).

16) Use of auctions as a means of regulating access only to congested bands (the Australian model).

17) The need for safeguards for assured market access for certain services.

18) The scope of safeguards against market abuse.

19) The nature of rights conferred by spectrum access rights including security of tenure.

**Secondary market (7.8-11)**

1.20 Users would have an added incentive to economise on their spectrum use if they were able to trade their spectrum assignments in a secondary market. This would mean that a market value could be established and make it easier for newcomers to acquire access to spectrum. Transfers of this kind would require a change in the current legislation, and be conditional on the change of ownership being notified to and agreed by the RA. A secondary market would be facilitated if rights had a duration fixed at a period of years.

1.21 If a secondary market were allowed, intermediary bodies might be established, acting as brokers or clearing houses for bringing together buyers and sellers. SMOs could play this role. A further mechanism would then be established by which the spectrum management process would be progressively privatised.

1.22 The Government is interested in exploring the feasibility of establishing a secondary market for trading spectrum rights. Views are invited on this general issue and on these specific points.

20) Would there be sufficient interest in such a market to encourage users to sell spectrum they no longer needed?

21) Would the existence of a secondary market, by encouraging such sales, promote more efficient spectrum use?

22) Would a secondary market make it easier than now for existing or potential users to acquire spectrum?

**Enforcement (7.28-38)**

1.23 If the rights conferred by licences change, so that a user has some form of right over the spectrum itself, rather than, as now, a right to use radio equipment within certain specified conditions:

23) how far should the RA retain the enforcement role, acting through the courts when necessary?

24) how far could SMOs be given a role in enforcing compliance by, and preventing interference to, radio users to whom they have provided rights to use specific areas of spectrum?

24) how far could licensees be made responsible for resolving their own interference problems, perhaps using a conciliation and arbitration service offered by Government before recourse to civil action in the courts?

**A possible outcome**

1.24 Finally, Chapter 8 outlines how the various possible elements of reform described in earlier chapters might be brought together. It provides a focus for discussion. The objectives of reform are to:

- promote more efficient spectrum use;
- ensure a non-discriminatory regime;
- add to the value users dervive from spectrum assigned to them (8.2).

1.25 The potential to enhance spectrum efficiency through:

- technology;
- geographical re-use; and
- sharing by usage pattern

is explained with examples (8.3-8.4)

1.26 Chapter 8 outlines a possible way in which the elements described in chapters 6 and 7 might be combined in practice. Pricing would be mainly administrative with incentives for efficient spectrum use. Auctions in selected parts of the spectrum would provide guidance about market prices. This would be combined with a continuing process of contracting out detailed spectrum assignment to several classes of SMOs based on, for example:

- cooperative arrangements between users with a common interest;
- commercial intermediaries (8.5-8.20).

1.27 Secondary markets would be facilitated within specific licence classes allowing trading in assignments (8.11) and this would provide additional guidance about market prices for spectrum.

1.28 The role of the Radiocommunications Agency would progressively shift from detailed licence assignment and be focused on the core functions that need to be carried out by government, including:

- managing the UK's international treaty obligations;
- frequency allocation between different classes of use and to SMOs;
- ensuring compliance with licence conditions and resolving conflicts (8.21-8.22).

1.29 Key areas for comment include:

25) what price level is required to provide adequate incentive for efficient spectrum use?

26) what is the scope for encouraging the development of private sector SMOs?

27) which are the core functions of spectrum management that need to be retained within Government?

# CHAPTER 2: INTRODUCTION

2.1 The radio spectrum is a limited natural resource subject to growing demand. It is of increasing significance for the development of the economy. Used by a growing number of industries and all sizes and types of company, it is also of great importance in other aspects of national economic and social life, including defence, the emergency services, the entertainment world and hobby and leisure use. But radio waves become useless if transmissions by one user cause an unacceptable level of interference to use by another. This potential for interference, together with the need for a stable planning framework and the desirability of opening up large markets, gives rise to the need to manage and regulate spectrum use.

2.2 It is important that the radio spectrum resource is managed well. As demand on it has increased, the management task has grown more complex. The international element of the task has grown steadily with the development of international radio-based services, the pressure to provide internationally harmonised frequencies and the importance of harmonising equipment standards in support of worldwide markets. In recent years, the need for the UK to take account of the European dimension in its spectrum management decisions has grown particularly rapidly.

2.3 Eventually, technology may remove the need for spectrum management in some areas, at least at the assignment [1] level, by enabling radio systems themselves to avoid interference. This would take away a major element of the management role. Some devices of this kind are already available, but it is likely to be many years before such developments substantially replace current spectrum management functions. Since technology will never remove the need for management at the allocation level, spectrum managers will continue to make allocation decisions between services to ensure effective operation of certain international services and to create the right competitive conditions for equipment markets to prosper.

2.4 The Government has already taken steps to liberalise and expand choice in the telecommunications and broadcasting markets. It is now time to consider further the management of the radio spectrum which has provided the means for much of the expansion in both these and other markets. As in the earlier initiatives, the Government approaches the current review with the aim of ensuring that any reforms to the legal framework provide the maximum freedom of competitive choice for all wishing to use the radio spectrum in accordance with the law.

2.5 This Consultative Document sets out options for a radio spectrum management policy for the future and is intended to stimulate comment and debate from interested parties. In the light of this, the Government will seek to introduce whatever changes appear desirable. Some of these changes may require legislation.

### Arrangement of Chapters

2.6 Chapter 3 sets out the current and prospective situation on use of the radio spectrum. The present management arrangements are described in Chapter 4. Chapter 5 considers possible improvements to these arrangements, involving changes which could be made without amending the existing statutory framework. Options for the future involving legislative change are discussed in Chapters 6 and 7. Chapter 6 outlines a model for changing the existing fees-setting regime while retaining the basis of the current spectrum management structure. Chapter 7 presents ideas for more radical change, including further privatisation of spectrum management, and auctions. The ideas in these two chapters are brought together in Chapter 8, which outlines a possible way forward.

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[1] **Terms of art:** use of radio is categorised by **service** (mobile, fixed, broadcasting etc) in accordance with internationally recognised definitions. At national level these services are further sub-divided in the UK into some 50 categories. The bands of the radio spectrum are **allocated** for use by one or more services, through the International Radio Regulations and in more detail by national governments. Users may be **assigned** a frequency by their national spectrum management authorities to operate a service in a band allocated for use by that service.

# CHAPTER 3:
# THE RADIO SPECTRUM

3.1 This chapter describes the characteristics of the radio spectrum, the distribution of services within it and the demand patterns for these services in particular spectrum ranges.

## CHARACTERISTICS OF THE RADIO SPECTRUM

3.2 In general, the lower their frequency, the further radio waves will travel. The higher the frequency, the more bandwidth is available, allowing more information to be transmitted per channel than at lower frequencies. As the frequency increases, the distance covered by radio waves from a transmitter of a given power will reduce because the waves have a greater tendency to obstruction and deflection by terrain and buildings. At extremely high frequencies, rainfall and other weather conditions can significantly limit the distance covered by radio waves. These propagation phenomena mean that:

- different frequency bands are best suited to particular types of radio use. For example, long and medium frequencies (150-1500 kHz[2]) are used for broadcasting over wide areas; short wave, HF (high frequency - 3 to 30 MHz) wavebands, for international broadcasting; VHF (very high frequency - 30 to 300 MHz) and UHF (ultra high frequency - 300 to 3000 MHz) bands, for television and local sound broadcasting and for mobile radio (becoming more local towards the upper end of this range);

- frequencies may be shared on a geographical basis. For instance, VHF frequencies used for local radio broadcast stations may be re-used up to 10 times within the boundaries of the UK, contrasting with re-use of medium wave frequencies of about three times within Europe. Further up the scale, at very high microwave frequencies (more than 30 GHz), frequency re-use of 100 times or more may be possible in the UK;

- long range transmission can be achieved using the low frequency ranges or higher power. Satellites and fixed link radio relay provide alternative means of communication over long distances.

## DISTRIBUTION OF RADIO SERVICES

3.3 Figure 1 shows the spread of the radio spectrum from the very low to the extremely high frequency (VLF to EHF) ranges. Figures 2-5 show, across defined spectrum ranges, the approximate percentage distribution of different types of radio use within the UK. It is not possible to give definitive figures for this distribution because many services share frequency allocations. The following paragraphs describe the distribution and potential growth areas for radio services in the spectrum.

## PATTERNS OF SPECTRUM USE, CONGESTION AND DEMAND

### Below 1 GHz

3.4 Below 1 GHz (Figure 2), about 40% of the spectrum is devoted to sound and television broadcasting, just under 30% to defence use and nearly a quarter to mobile radio use - both national network operators and private mobile radio (PMR) users. The remainder is divided between aviation and maritime use and miscellaneous other uses such as amateur radio and space observation.

3.5 Spectrum congestion is at its most severe below 1 GHz, although only in one area of the spectrum has overcrowding reached the stage where the RA has had to announce that it will stop making new assignments: PMR use in about 8 MHz in high band VHF frequencies within the M25 area around London. The annual rate of growth in PMR has averaged 8% over the past ten years. The growth rate over the past year, at 5%, is slightly down on previous years but the overall trend remains upwards. There is significant potential for future growth in use of mobile radio in

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[2] 1000 kHz = 1 MHz; 1000 MHz = 1 GHz

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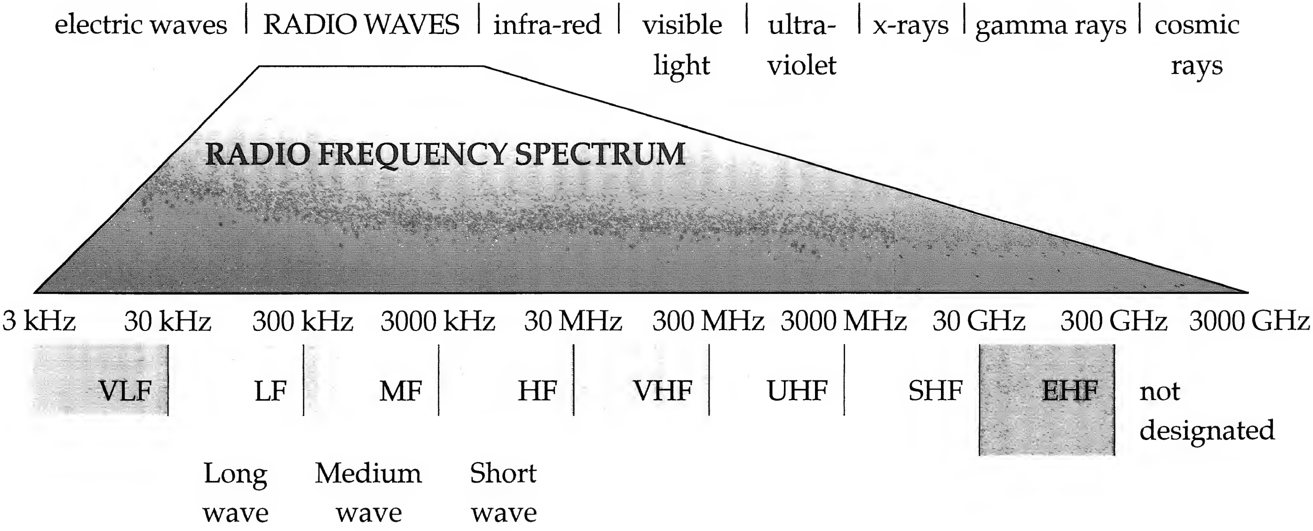
# ELECTROMAGNETIC SPECTRUM

## Showing the
## Radio Frequency Spectrum



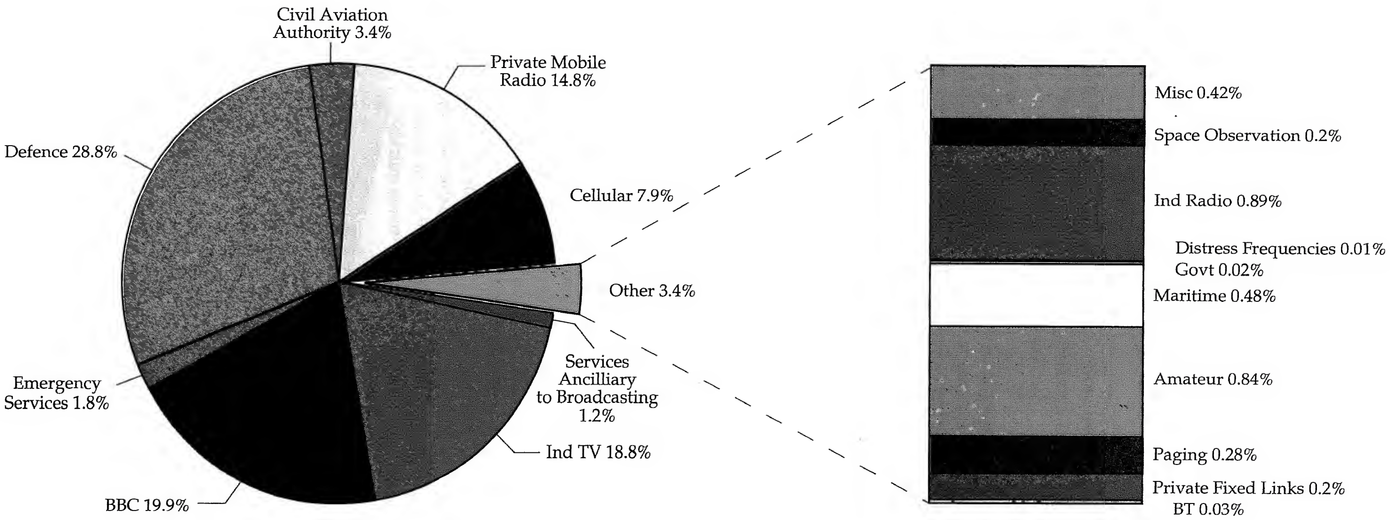
| | | | |
|---|---|---|---|
| VLF | Very Low Frequency | VHF | Very High Frequency |
| LF | Low Frequency | UHF | Ultra High Frequency |
| MF | Medium Frequency | SHF | Super High Frequency |
| HF | High Frequency | EHF | Extremely High Frequency |

**Figure 1**

*Not to scale*

# Distribution of the Radio Spectrum

## 9 kHz to 1 GHz



many business sectors where levels of use are currently low. Much of this potential demand will be met by public services (e.g. cellular radio), but much also can be expected to be met by conventional PMR. There are currently over 28,000 PMR licensees, with the number of users of PMR exceeding 800,000.

3.6 In recent years, the Government has found spectrum below 1 GHz for public mobile services in the form of two national cellular radio networks and four telepoint services, as well as for personal communications network (PCN) operators in the range up to 3 GHz.

3.7 Sound broadcasting is another area of very strong demand growth within this spectrum range following the expansion encouraged by Government policy. Spectrum has been found to enable a large number of new local radio and other types of station to broadcast services. But it is becoming increasingly difficult to find space in the spectrum to permit further expansion of such services.

3.8 Similarly, spectrum was found to enable a franchise to be advertised for a fifth terrestrial TV channel covering about 70% of the population. However, tentative proposals for a sixth channel under consideration by the Government at one time had to be abandoned for lack of spectrum.

3.9 Some services, notably PMR and sound radio broadcasting, can only be accommodated cost-effectively in the lower spectrum bands because of the limitations caused by the physical characteristics of radio waves. In certain parts of the UK, in the mobile radio bands especially at VHF, and in the broadcasting bands at VHF and UHF, there is only limited scope for increased use unless technologically advanced equipment and spectrum efficient techniques are introduced on a wide scale.

3.10 In these and other frequency bands below 1 GHz, better use of available spectrum has been achieved by sharing arrangements between military and civil users. Work continues on identifying other suitable bands for shared use.

**1-3 GHz**

3.11 Between 1 and 3 GHz, (Figure 3) the picture alters, reflecting the progressively changing nature of radio wave propagation. Less than 2% of this range is used for PMR; about 8% is allocated to personal communications networks (PCNs); and about 12% for services ancillary to broadcasting. The defence share is 30% and civil aviation occupies 15%. The current allocation to public fixed links and fixed satellite services is 20% while other fixed links use nearly 6% of the spectrum in this range.

3.12 Despite considerable demand pressure, there are frequency bands in the range up to 3 GHz where occupied spectrum is not and cannot be fully utilised at any one time. In the case of spectrum used for defence purposes, this is because radio operators require the flexibility to change frequencies at short notice to avoid jamming and other operational problems. In other cases, spectrum may have been reserved for new services such as the PCNs or the cordless European telephone services (DECT), or allotted to allow for further growth.

3.13 At the frequencies in the middle of this range, particularly 1.5 to 2.5 GHz, there are increasing pressures for further mobile radio services. Both the PCNs and DECT will be accommodated here, as will the future generation of public mobile systems. The development of the new public mobile radio services also involves use of fixed link bands above 3 GHz, needed for the infrastructure supporting these services.

3.14 The Duopoly Review, published in 1991[3], has encouraged further interest in this part of the spectrum, since potential operators see attraction in using radio in competition with British Telecom (BT) for delivering services to the end user relatively quickly.

3.15 In addition, the frequency range to 3 GHz is ideal both for television outside broadcasting links such as those used for news gathering, and for mobile applications such as those needed for sporting events. These links use considerable amounts of spectrum and the demand is increasing as more television services, including satellite channels, are introduced. Provisions were agreed at the 1992 World Administrative Radio Conference (WARC), for accommodation in the

---

[3] Competition and Choice: Telecommunications Policy for the 1990s, A Consultative Document, Cm 1303, published by HMSO November 1990. Competition and Choice: Telecommunications Policy for the 1990s, White Paper Cm 1461, published by HMSO in March 1991.

# Distribution of the Radio Spectrum

## 1 GHz to 3 GHz

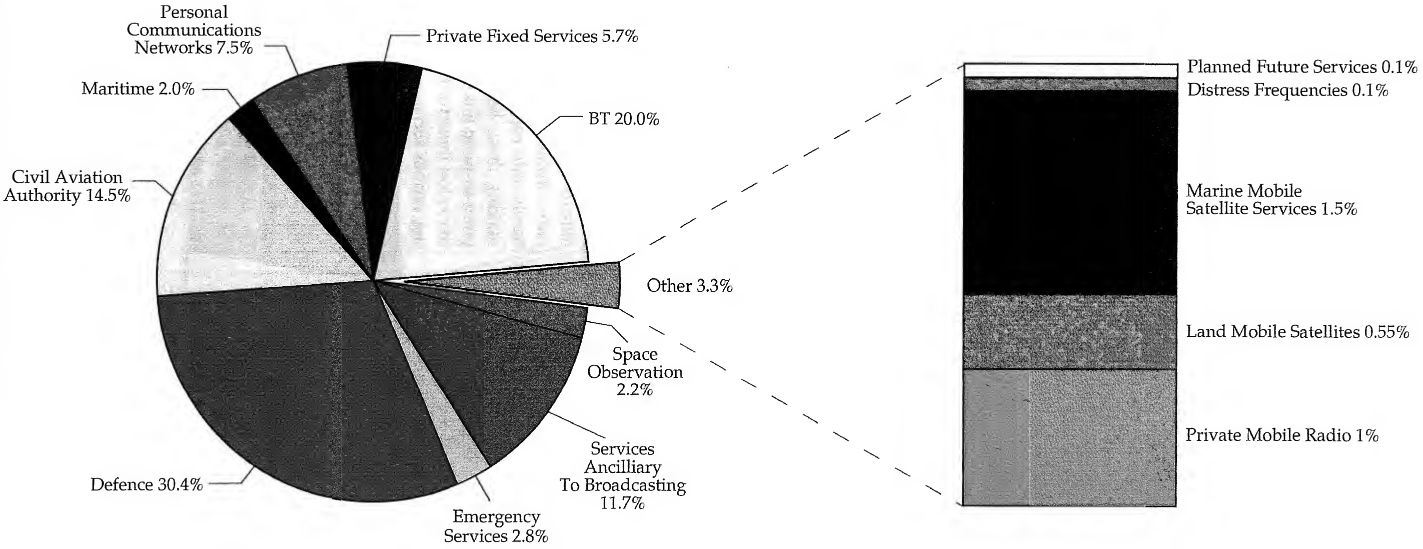


Figure 3

future of new services such as international mobile services via satellite and high quality sound broadcasting services and High Definition Television (HDTV) by satellite. HDTV will require ancillary services below 3 GHz. The demand for spectrum for services like these could not be anticipated even a few years ago.

### 3 GHz to 30 GHz

3.16 Between 3 and 30 GHz, the super high frequency (SHF) range (Figure 4), there is no traditional mobile use. Broadcasting use of 6% of the spectrum is confined to the broadcasting satellite service and services ancillary to broadcasting. The defence share is 38% and the former duopoly public telecommunications operators have 32% (BT 22% and Mercury Communications 10%). The largest remaining share, 7%, is for fixed links for private operators, with the remainder divided between fixed satellite, civil aviation, maritime, space observation and other uses.

3.17 In most of the SHF range, congestion is not yet a problem but, in some areas of the UK, there is demand for wide band terrestrial fixed links which cannot be met because of congestion. For instance, in the 7.5 and 13 GHz bands, there is some overcrowding where many operators require similar links in the same or neighbouring geographical areas.

3.18 Most of the SHF range is already in use or committed for use under international agreements. Much is reserved for civil and military radar applications in the aeronautical and maritime fields where significant changes to use could be made only by international agreement because of the worldwide nature of air and sea transport. Commercial development of new applications and design of new commercial equipment for exploiting these radar bands is therefore unlikely.

3.19 For other parts of this spectrum range, however, the prospects for development of competitive commercial services look brighter for such uses as fixed links for telecommunications. This is because the bands between 3 and 30 GHz can carry large amounts of information per radio channel. When used in conjunction with satellites or fixed link radio relay, they can be used for communication over long distances, using, at the higher frequencies, many fixed link "hops". Radio links can be installed more quickly and conveniently than cable. Following deregulation of the telecommunications market, these bands are therefore attractive to potential new operators.

3.20 Much of this spectrum has historically been reserved for the exclusive use of BT but, following a recommendation of the Stage 2 Spectrum Review Committee (see paragraphs 4.23 and 5.14), the Radiocommunications Agency (RA) is in the process of taking back management control of some bands from BT. This will enable these bands to be opened to commercial use by others, while still taking account of BT's requirements as one of the Agency's largest customers.

### Above 30 GHz

3.21 The most noticeable difference between the distribution of services shown in Figure 5 and those shown in Figures 2, 3 and 4 is that more than half the spectrum in the range 30 to 100 GHz (the Extremely High Frequency or EHF range) is unoccupied. The millimetric bands above 30 GHz are subject to severe attenuation of signals by atmospheric moisture and by gaseous absorption, making them suitable only for short range communications. However these physical effects mean that intensive spectrum re-use is possible.

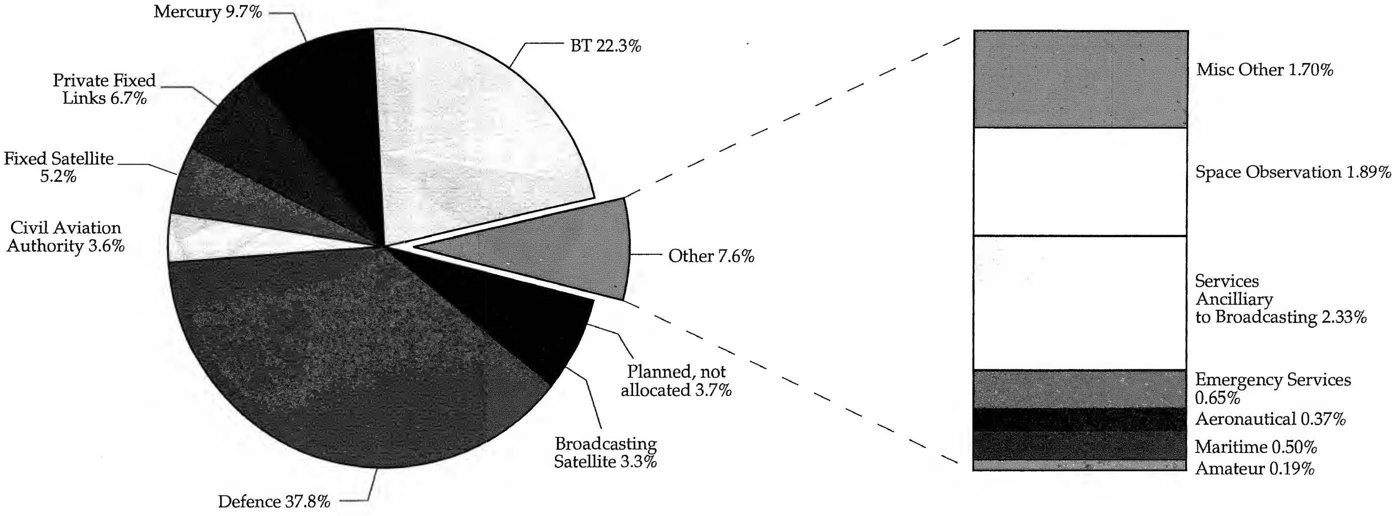
3.22 Almost all the current use of the range is below 60 GHz. Until recently there was little commercial use of these bands, partly because of the technical limitations of existing equipment. In the past, these frequencies were only considered suitable for certain types of radio use - radio amateurs, radioastronomy and military - but they have large bandwidths capable of carrying high traffic levels, making these bands particularly well suited to point-to-point links. The RA has encouraged users to exploit them for fixed links needed for supporting various services. Several new fixed link applications, such as those used for the infrastructure of the personal communications networks (PCNs) are being accommodated here.

3.23 The UK has taken the lead in gaining agreement in Europe for harmonised frequency plans for several specific applications such as MVDS (Multi-point Video Distribution Systems) around 40 GHz and fixed links at 38, 55 and 58 GHz.

3.24 There is unlikely to be any congestion in the EHF bands for some years. Indeed, there is little prospect of the higher frequencies in the range

# Distribution of the Radio Spectrum

## 3 GHz to 30 GHz



# Distribution of the Radio Spectrum

## 30 GHz to 100 GHz

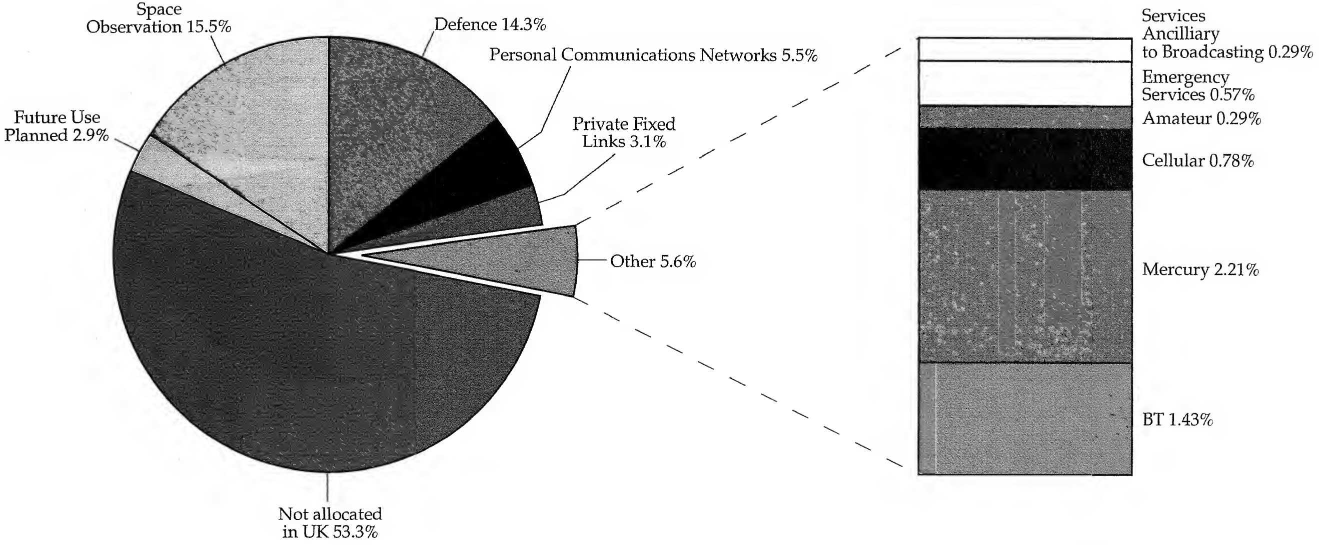


**Figure 5**

being exploited commercially for the foreseeable future and even then their physical characteristics would limit their range of use. This situation however may change, possibly rapidly, as technology develops.

## IS CONGESTION A PROBLEM?

3.25 The preceding paragraphs summarised the present and prospective patterns of use across the commercially exploitable range of the radio spectrum, highlighting areas where congestion is already observable. It is difficult to assess how far economic activity is restricted by congestion in bands, such as the private mobile radio bands, where demand is high. Aware of potential difficulties with PMR use, some users may already be turning to alternative services, without applying for a radio licence. The real level of frustrated demand may therefore be greater than appears.

3.26 It is also difficult to gauge how much assigned spectrum is surplus to licensees' requirements. Intensive monitoring exercises give only a snapshot of spectrum use over a short period. To give an indication of trends over time, repeated exercises are needed. These can aid both prediction of growth in demand and identification of under-used spectrum where there is surplus capacity. The RA has begun a programme of such exercises. Until sufficient data has been accumulated, wholly reliable estimates cannot be made of the amount of spectrum held in reserve, under-used by licensees, to accommodate planned or potential future growth. But, as demands on the spectrum continue to multiply, there must be a risk that competitive opportunities will be limited by non-availability of spectrum in the more congested bands. In these circumstances, market mechanisms could provide one means of distributing the available spectrum.

3.27 Almost all radio users have alternative means open to them for meeting their communications needs. This may however involve higher equipment costs or use of, for instance, a shared or public mobile communications network rather than a private system. Standard PMR users prefer assignments in the VHF range because signals can cover longer distances for a given power, but some new users have to accept frequency assignments different from those they applied for. In sound broadcasting, the medium preferred by broadcasters and listeners is now VHF/FM. Current and foreseeable pressure on VHF Band II means, however, that many services must accept the less desirable alternative of medium wave AM, as occurred with the second and third independent national radio networks.

3.28 In 1987, the report "Deregulation of the Radio Spectrum in the UK" by CSP International (commissioned by the DTI and published by HMSO) estimated the economic losses associated with what they described as "access restrictions" on the radio spectrum resulting from the management arrangements at the time as "many tens of millions of pounds per year". CSPI suggested this loss was unnecessary since in overall terms there was "no prospect of general spectrum shortage for the foreseeable future". While it is difficult to verify such estimates with precision (and while it is possible CSPI underestimated the technical and international constraints on introducing more flexibility of access), the Government had no reason at that time to dissent from CSPI's broad conclusion. Recent improvements in spectrum management (summarised in paragraph 4.25 of the next chapter) have been in part a response to these conclusions.

3.29 Since 1987, demand pressures on the spectrum have grown further, particularly in the lower spectrum ranges where broadcasting and mobile radio uses predominate. In these ranges, the importance of international allocation agreements is apparent. Changes in use alter the balance between allocations and take time. Fitting new services using new technologies into spectrum has to be done at the European level if, for instance, the new European mobile communications services are truly to be usable Europe-wide.

## CONCLUSIONS

3.30 Growth in demand shows relatively little sensitivity to trends in the economy as a whole. It therefore seems possible that spectrum use in the UK may reach a point, perhaps within the next decade, where substantial numbers of new users and new services may not be assigned frequencies in the spectrum bands most suited to them.

Significant improvements in spectrum management and spectrum efficiency have taken place in the past few years, but further modification to overall spectrum management policy may be necessary.

3.31 The next chapter outlines the Government's current spectrum management methods, before Chapter 5 considers what further modifications and improvements could be made under existing legislation.

NOTE: More detailed information on current and prospective use of the spectrum in the ranges 470 MHz to 3.4 GHz, 3.4 to 30 GHz and 28-470 MHz, is contained in the Reports of the Stage 1, Stage 2 and Stage 3 Spectrum Reviews (1988/1989, 1991 and 1994). These are available from the RA Library, Waterloo Bridge House, Waterloo Road, London SE1 8UA. Further reference will be made to these important independent reports in later chapters of this document.

# CHAPTER 4
# THE PRESENT SYSTEM OF SPECTRUM MANAGEMENT IN THE UK

4.1 As in all other countries which are members of the International Telecommunication Union (ITU), the Government in the United Kingdom undertakes the task of overall radio spectrum management, but with a substantial element of delegation to other bodies.

4.2 Within the Government, the main body responsible for spectrum management is the Radiocommunications Agency (RA), an Executive Agency of the DTI, established under the Government's "Next Steps" programme in April 1990.

4.3 The RA takes the lead for the UK in ITU discussions of radio issues, including the World Administrative Radio Conferences (WARCs).[4] However, the RA does not have the delegated authority to determine the broad balance of allocations of the spectrum in the UK between (for example) civil and military use within the constraints imposed by international agreements. That function is performed centrally through agreements made between the Government's spectrum-managing departments. The Ministry of Defence is responsible for the management of spectrum allocated for military use; and certain other Government Departments and bodies (e.g. the Home Office, Scottish Office, National Air Traffic Control Service) are responsible for the management of specific blocks of spectrum for use by services within their areas of responsibility.

4.4 The following sections describe the constraints within which any spectrum management body must work, and how the Government is approaching the task under the present arrangements.

## SPECTRUM MANAGEMENT

4.5 Spectrum management policy cannot be considered in isolation. There are strong links between this and other areas of Government policy, in particular defence, telecommunications and broadcasting policies. In a more general sense, spectrum managers need to be alert to virtually every area of Government policy and trends in national economic and social life, as well as to technological developments.

4.6 With all the constraints imposed by international agreements, past decisions and existing uses and investments, spectrum planning needs to be carried out at a strategic long term level to take account of foreseeable technical and commercial changes over a period of up to twenty or more years ahead. Equally, however, spectrum managers need to be responsive to short term competitive pressures for new services, perhaps resulting from an international agreement, a change in Government policy or a technological breakthrough. They must have accurate information on what allocations and assignments have been made and what use is being made of them. This implies the need for a robust database and a monitoring capability. They need both the ability to take a broad overview to decide where new services can best be accommodated and the power to move existing users to alternative parts of the spectrum if necessary.

### International dimension

4.7 The ability of any spectrum management body to take independent decisions is increasingly constrained by international agreements. These are reached in the interests of promoting international markets for manufacturers and network operators and for the convenience of the end users of radio. For users of such services as GSM (the European digital cellular radio system) and DECT (European Digital Cordless Telephone), the aim is to achieve transferability and continued use of equipment across national boundaries. At the world level, through the internationally binding Radio Regulations, the ITU determines what bands shall be allocated to particular radio services. Depending on technical considerations and propagation characteristics, these Regulations may allow individual administrations greater or lesser freedom of choice in making allocation decisions, on a regional or national basis. The UK plays a full part with other Administrations in shaping the Regulations, and has always taken a prominent role in the ITU in the interests of UK operators and manufacturers.

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[4] Following decisions taken by the ITU in December 1992, the various organs of the Union have been reorganised and renamed. The WARCs are now known as WRCs.

4.8 Other international bodies such as NATO, ICAO (International Civil Aviation Organisation) and IMO (International Maritime Organisation) may impose further restrictions on national spectrum management organisations through treaty obligations in their respective fields. Common frequencies are agreed for international air and sea transport navigation and safety services.

**Europe**

4.9 EC considerations are an important factor in radio spectrum management. The Council of Ministers has agreed a number of directives and resolutions concerning harmonisation of frequencies for Community-wide services.

4.10 Within Europe, the European Radio Committee (ERC) of the Conference of European Postal and Telecommunications Administrations (CEPT) is growing in importance. It covers a wider area than the EC, bringing together the spectrum management authorities of over 35 European countries, including several former eastern bloc states. From 1990-1992 the ERC was chaired by a representative of the RA.

4.11 The ERC is developing a significant role in promoting alignment of frequency use in Europe and in harmonising regulatory regimes, equipment type approval procedures and arrangements for the mutual acceptance of licences between countries. Its importance was emphasised in November 1992 by the EC Telecommunications Council of Ministers' withdrawal of two EC frequency directives in recognition of the adoption in the ERC of Decisions in the same field of frequency harmonisation, which CEPT member countries may commit themselves to implement. Nevertheless, the Commission will retain a vital role in developing EC telecommunications and hence radiocommunications policy. Its continuing commitment to activity in this area has been demonstrated by its funding of two wide-ranging recent studies on licensing and frequency allocation in EC Member States.

**Frequency co-ordination**

4.12 Once frequency allocations have been determined, it is often necessary to reach international agreement on the use of specific frequency assignments, when radio transmissions may stray across national boundaries. This process is called frequency co-ordination and the procedures depend on the application. For satellite services, co-ordination is carried out on a world-wide basis via the ITU in Geneva. For broadcasting services, whether terrestrial or satellite, a detailed frequency assignment plan is normally drawn up on a regional basis within the ITU framework. This is also done for aeronautical and maritime mobile services although the planning is generally less detailed.

4.13 For other services, frequency co-ordination, if necessary, is carried out on a bilateral or multilateral basis either using internationally agreed procedures or via a specific agreement. Modification procedures laid out in the international plans also require bilateral or multilateral co-ordination of changes. The UK is party to several specific agreements with neighbouring countries. One example covers the use in the UK of the international VHF broadcasting Band III for mobile radio.

**The Radiocommunications Agency**

4.14 Operating within the policy and international constraints described above, the UK spectrum management authorities have developed a style of operation aimed at meeting the developing demands on the spectrum described in Chapter 3. This approach is continuously evolving in an attempt to respond to the demand pressures - as witness, for example, the conversion of the former DTI Radiocommunications Division in 1990 into an Executive Agency with a more commercial management framework.

4.15 In describing the current approach and policies, the following sections concentrate on the RA as the spectrum management body most directly involved with the majority of commercial and social users of the radio spectrum in the UK.

## Functions of the RA

4.16 The RA aims to provide a high quality spectrum management service to its customers, who are all the current and potential users of radio who operate within the law. As far as possible, consistent with its responsibilities to Government customers, the Agency works to maximise the amount of spectrum allocated for non-Government use, for both commercial and domestic or leisure activities. The Agency aims to ensure the optimum use of the spectrum in the overall economic and social interests of the UK.

4.17 The RA does this by:

a) planning future spectrum use. This has to take account of decisions and agreements made on spectrum allocations at the international level and of likely domestic developments. Plans are made in consultation with radio users, network operators, service providers and manufacturers, as well as with other Government departments. Contacts with consultative committees (paragraph 4.22) and the programme of independent Spectrum Reviews (paragraph 4.23) are of considerable importance in this process;

b) participating in international negotiations on allocation issues and technical standards and regulations;

c) ensuring compliance with international agreements, European standards and relevant European Community recommendations and Directives;

d) planning at a more detailed level, making assignments for individual users;

e) regulating the use of radio equipment where necessary. This is done by licensing use of equipment in accordance with the Wireless Telegraphy Acts[5], by setting equipment standards and type-approving equipment and by investigating and taking enforcement action under powers contained in the Wireless Telegraphy Acts and other legislation[6] to stop or reduce interference;

f) monitoring use of the radio spectrum. As well as providing data for interference investigations, knowledge of actual use is important to the spectrum planning process and to efficient assignment capability;

g) ensuring there is an adequate programme of research to improve spectrum management in the future;

h) providing UK users, manufacturers and installers of radio equipment with information and advice.

## Fees-setting

4.18 Licence fees are charged for all use of radio transmission equipment except where equipment has been made licence-exempt. The frequency or frequencies assigned to a user and the conditions of operation such as location, antenna height and transmission power are specified in the licence. Fees are set in regulations laid before Parliament and are reviewed annually. Not all fees are set in the fees regulations. Some, such as the charges paid by Government departments and major spectrum users such as BT, Mercury Communications and the BBC, are determined individually by the Secretary of State. These Government departments and major users contribute to the cost of spectrum management in the UK. The charges paid by them include an element related to the amount of spectrum allocated for their use and also include the direct cost of work carried out for them by the RA.

4.19 Under existing rules, the Agency is required to cover the full costs it incurs in managing the spectrum. Details of the Agency's expenditure and income are published in its Annual Report. In each of the three full years since the Agency was formed, targets to improve financial efficiency by 3%, 3% and 2% respectively were met, confirming successful cost constraint in the face of increasing demand. Average fee increases have been well below the rate of inflation, reflecting this progressive improvement in efficiency. The Agency will be required to continue meeting efficiency targets in subsequent years; the efficiency gain target for 1993/94 is 4%.

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[5] In accordance with the Government's deregulation initiative and the principles of the Citizen's Charter, the Agency has a continuing commitment to exempt radio use from licensing where possible. A large number of low power radio devices (including cordless telephones) have been exempted from licensing in recent years.

[6] The relevant Acts are the Wireless Telegraphy Acts 1949 and 1967, the Marine, & C., Broadcasting (Offences) Act 1967, the Telecommunications Act 1984 and the Broadcasting Act 1990.

### Style of management

4.20 The Agency recognises that users' needs are paramount and should drive spectrum management, not vice versa. It is conscious of the many interests of its customers and adopts an open style of management, consulting them and taking action on a consensus basis where possible. In 1991, the Agency commissioned the first-ever professional survey (by MORI) of the views of its customers on the quality of spectrum management service provided to them. The results showed that, in general, the Agency is carrying out its spectrum management functions to its customers' satisfaction. The RA was found to be more approachable and responsive to customers' needs than its predecessors. The marked decrease in average licence processing times since the Agency was established was particularly welcomed. But the survey showed there was room for improvement in other areas, such as the time taken to deal with difficult cases, accuracy of records, availability of data, clarity of information and accessibility of staff. In the light of the survey, the Agency has taken steps to tackle customers' concerns and has commissioned a follow-up survey (also by MORI) as part of its ongoing commitment to improving service standards. It intends to repeat this annually.

4.21 Customers also favoured the idea of the RA's local District Offices taking over responsibility from the London headquarters of the Agency for making frequency assignments and issuing licences for standard private mobile radio (PMR). Pilot trials in the north of England, Scotland, Northern Ireland and the south London District Offices showed that turn-round times between licence application and issue were maintained. A reduced incidence of co-channel complaints indicated that the quality of frequency assignments had benefitted from the local knowledge of District Office staff. The Agency has now extended local processing for standard PMR licences to all its local offices and expects better use of the spectrum, as well as better customer service, to result from this change in procedure.

### Consultative Committees

4.22 The RA has set up formal consultative committees covering civil land mobile radio, microwave fixed links and broadcasting services, to discuss spectrum management issues on a regular basis. Frequent consultations also take place with a wide range of associations, federations and groups of radio users and equipment manufacturers, as well as with individual organisations.

### Spectrum Reviews

4.23 A development of major importance to spectrum management in recent years has been the programme of independent spectrum reviews set up following a recommendation of the Merriman Committee in 1983[7]. These reviews give thorough consideration to the existing and prospective use of blocks of the radio spectrum, taking evidence from users, service providers and manufacturers, and make recommendations to Government. Three such reviews have so far been carried out, covering the ranges 470-3400 MHz (the Stage 1 Review), 3400 MHz-30 GHz (the Stage 2 Review) and 28-470 MHz (the Stage 3 Review).

4.24 The Review reports have been published and have provided a detailed basis for policy making. The Government accepted all the main recommendations of the Stage 1 Review. The Stage 2 Review (published in 1991) and the Stage 3 Review (published in 1994) made a number of important and far-reaching recommendations to Government, including recommendations on managing the spectrum; these were among the influences on the present consultative document[8]. The Government has not yet responded to the recently published Stage 3 Review.

### Specific actions

4.25 The RA has employed many different measures for improvement of its spectrum management capability and effectiveness in response to the dynamic movement of market demand. Among the more significant measures the Agency has:

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[7] Report of the Independent Review of the Radio Spectrum (30-960 MHz) Cmnd.9000, published by HMSO in July 1983. This Committee, chaired by Dr J H H Merriman, was responsible for recommending many of the improvements in spectrum management of recent years.

[8] Copies of the Reports of the Reviews are available from the RA Library, Waterloo Bridge House, Waterloo Road, London SE1 8UA; telephone 071-215 2352.

a) organised sharing arrangements between major users and new market entrants. The increasing number of bands shared between civil and military use is an important recent development;

b) persuaded major users to give up spectrum; for example, the personal communications network operators (PCNs) have been allocated frequencies given up by BT;

c) persuaded users to move to higher, less congested spectrum bands;

d) successfully encouraged the exploitation of, and reached international agreements on, the use of the frequency bands above 30 GHz for fixed services;

e) embarked on a programme of resuming management of blocks of spectrum in the 3 to 30 GHz bands historically allocated for the exclusive use of certain large licensees, to facilitate more efficient shared use of these bands and make room for different users;

f) market tested a substantial range of its activities (and as a result has put out to the private sector, for example, the bulk of equipment type testing work and the licensing of CB and Amateur radio) and is in the process of marketing testing marine licensing;

g) encouraged the formation of user spectrum management groups, who have an interest in the efficient management of defined blocks of spectrum allocated for use of their members;

h) backed research into new technology leading to development of equipment able to deliver the required quality of communications using less spectrum;

i) promoted the use of techniques such as single side band transmission, trunking and co-channel sharing to increase the number of users able to use particular bands;

j) made increased use of sophisticated planning techniques for, for example, satellite and broadcasting services;

k) established a programme of detailed monitoring of the PMR bands, for planning, assignment and enforcement purposes;

l) enforced loading criteria and withdrawn channels from licensees when loading levels no longer justified their retention;

m) contributed to the adoption of standards and performance specifications which, when used by the radio industry, aid efficient spectrum use and achievement of acceptable interference levels;

n) enhanced enforcement resources so that users can have better quality communications free from interference; and sought and obtained approval from Parliament for more effective powers to combat unlicensed use;

o) invested substantially in additional well-qualified engineering staff and computerised spectrum management tools.

4.26 Taken together, these measures show that the Agency is responding dynamically to its spectrum management responsibilities. It intends to continue these activities, intensifying them where possible. But it is clear that pressures on the spectrum are growing. There are limits to what can b done to relieve them under the present system **The Government hopes that respondents to th document will give their considered assessme of what has been achieved, of what more shou be done and of the overall quality of spectru management as practised by the RA.**

NOTE: This Chapter has necessarily given a highly sumr account of the role and activities of the RA. More detail found in the Annual Report of the Agency; the latest edit available from the RA Library, Waterloo Bridge House, Wa Road, London SE1 8UA; telephone 071-215 2352. The RA publishes a wide range of information sheets and booklets on p ticular services.

# CHAPTER 5
# WHAT MORE CAN BE DONE UNDER EXISTING LEGISLATION?

5.1 This Chapter outlines what more could be done within the existing legislative framework towards ensuring that radio spectrum management in future fully meets the demands likely to be placed on it. Chapters 6 and 7 deal with options which would require legislative change.

## Broad principles

5.2 The Government considers the radio spectrum should be managed to the overall benefit of the economy in its broadest sense. This means taking account of the interests not only of large firms but also of small companies and new market entrants, as well as of humanitarian, charitable and leisure uses of the medium. Efficient spectrum management should ensure that those with economic power do not abuse this power in relation to weaker but otherwise viable users. The management regime should aim to obtain the optimum value from the spectrum in support of a competitive, open economy, but avoid squeezing out "non-economic" users. This will require a careful balance to be struck.

## Developments in other countries

5.3 A number of other countries have identified a broadly similar pattern of growing pressure on their spectrum management systems, and have responded in a range of ways. In general, although countries are adopting or considering various methods for dealing with increased demands for spectrum, they have in common a desire to introduce market forces to a greater degree into spectrum management, with the aim of ensuring more effective use of the spectrum. In Australia and New Zealand, quite radical but differing changes have been introduced through new legislation. The Canadian Government has decided to continue with its existing arrangements, while keeping potential change under review. Annex A to this document contains a summary of the present position in these and some other countries to which reference will be made where relevant in later sections.

## ORGANISATION OF MANAGEMENT ARRANGEMENTS WITHIN UK GOVERNMENT

5.4 Chapter 4 showed that spectrum management consists of many interlinked activities. The functions of regulation, licensing and enforcement are under the authority and overall control of Ministers and are not confined to one Department. The vital planning aspects of spectrum management at the broad allocation level are carried out interdepartmentally, with the RA in the lead, while international negotiation and coordination are carried out by the RA, in liaison with and on behalf of all UK interests. These functions underpin the detailed aspect of spectrum management most visible to spectrum users: regulation of spectrum use by the assignment of frequencies to individual users.

5.5 The question of which aspects of spectrum management in the UK could be undertaken by bodies other than the Government is discussed in Chapter 7.

5.6 Assuming that overall spectrum management responsibility remains with the Government (as, without legislative change, it must) the organisational structure within Government will have to be the most effective possible. In general in recent years, radio users and the radio industry have been supportive of developments in the Government's spectrum management activities at the executive level. In contrast, the Stage 2 Spectrum Review report was critical of the Government's handling of strategic issues affecting spectrum management, and proposed the creation of "a new high level Committee within Government and reporting to Ministers to oversee national and international work in radiocommunications". The Committee took the view that a strategic approach was needed to issues such as encouragement of increased use of shared systems for more effective use of the spectrum and planning for the longer term so as to avoid disruptive frequency changes to users and give confidence for investment in equipment and infrastructure. The Stage 3 Review endorsed this view.

5.7 The Government will consider possible changes to organisation of its internal planning and decision-making arrangements in the light of responses to the many issues raised by this document.

### Independent Advisory Committee

5.8 A further recommendation of the Stage 2 Spectrum Review was that an independent advisory committee on spectrum management issues should be established, reporting directly to Ministers. While appreciating the concern underlying this recommendation, the Government considers that the independent Spectrum Review Committees themselves perform the function of providing independent advice to Ministers. Its intention is to continue the programme of Spectrum Reviews, covering different spectrum ranges on a planned and rolling basis.

5.9 Members of Spectrum Review Committees are selected for their particular expertise in the spectrum range under review as well as their general knowledge of radio issues. These Committees provide the required level of specialised, high quality independent advice, without being unwieldy and over-bureaucratic. In contrast, a standing advisory committee would necessarily be large if it were to be properly representative of the wide range of interests in the radio spectrum as a whole. One way of overcoming the problem of size might be to form sub-groups for discussion of particular issues. The Stage 3 Review broadly agreed that consultations with a wide range of interests channelled through the RA would be more effective than an advisory committee, although the report went on to recommend that existing consultation arrangements should be reviewed to ensure that they go wide enough.

**5.10 The Government would be interested to receive views from respondents to this document on the need for a standing independent advisory committee and how the independence and effectiveness of such a body could be ensured.**

## EXTENSION OF SELF MANAGEMENT ARRANGEMENTS

### Existing arrangements and future policy

5.11 Over recent years the RA has made arrangements for assignments to be made and, in some cases, licences to be distributed by other bodies, subject always to the overall control of the RA. More than 50% of the total number of licences issued by the RA are handled in this way. Distribution of Citizens' Band and Amateur radio licences on behalf of the RA is contracted out and there are several bodies with self-management and assignment responsibilities for specific user groups. These are the Joint Frequency Management Group for programme making by the BBC and independent television and radio companies; ASP (Association of Service Providers) Frequency Management Limited for the independent film production companies and foreign broadcasters, and the JRC (Joint Radio Committee) of the fuel and power industries, which has a mobile spectrum allocation for self-assignment by the industries. The water industry agreed a self-management arrangement in 1991.

5.12 These arrangements have generally worked well. They are characterised by each management body planning the frequency assignments within a small amount of spectrum allocated for its own exclusive use. Each group knows it has to accommodate any increased demand within its allocation. One potential drawback is that any significant extension of self-management arrangements could carry with it a risk that self-management bodies in competitive industries could restrict market entry by newcomers. There is no evidence of this having occurred as yet. The Agency intends to respond constructively to approaches from other bodies, if quality of service and spectrum efficiency can be expected to result.

5.13 Self-management has also been a feature of the large exclusive block allocations made to individual fixed link users such as BT and Mercury The Government is pursuing a policy of retrievin these blocks back into management by the RA s as to be able to accommodate further users in addition to the existing operators.

## TELECOMMUNICATIONS POLICY

5.14 In the past, spectrum management has been carried out to a considerable extent independently of telecommunications policy. A change in this situation was accelerated by the Duopoly Review and accompanying changes in telecommunications policy. The Government is working to achieve an appropriate balance of policy in this area.

**Moves to Cable**

5.15 One of the issues highlighted by the Stage 2 Spectrum Review was that, while some radio services could only be accommodated in certain bands because of the propagation characteristics of those bands, other services using radio as a cheap and convenient means of communication had non-radio alternatives from which to choose. The Spectrum Review Committee specifically recommended that "as a general principle, fixed links traffic within mature networks should be carried by cable wherever practicable to release spectrum for other uses".

5.16 The Government does not consider it should go so far as to refuse radio licences solely on the ground that alternative media are available. It does not intend to affect operators' viability by arbitrarily forcing them to use cable. As a matter of general principle, the Government considers that operators of services should choose between operating media on the basis of the opportunity costs of the various alternatives. At the present time this may well not happen and the Government considers it would be desirable to take steps to clarify the economic choices facing operators.

5.17 The Government is committed to increasing consumer choice in telecommunications through the introduction of new services and the promotion of further competition into the telecommunications market. A number of the companies which have applied for new operating licences since the liberalisation of policy which followed the Duopoly Review in March 1991 are proposing to use radio-based technologies. Radio-based services often offer a rapid means of entering the market, particularly at the local level, at a lower market cost than that associated with cable. The Government's intention is to permit the use of radio as a means of entry into the market and then, as cash flow and traffic increase, and where feasible, to encourage moves from fixed links to cable. Possible means of doing this using price mechanisms in support of administrative measures are discussed in Chapter 6.

5.18 The rapid expansion in the mobile market has been based almost entirely on radio and the mobile telecommunications operators are likely to be an increasingly important source of competition to the established fixed operators. There are also areas where radio fixed links are likely to continue to be the most cost-effective way of providing particular parts of the mobile operators' networks. While there may therefore be some scope for reducing established operators' dependence on radio, the demands of the telecommunications industry as a whole for spectrum are set to increase over the next few years.

## PROGRESS ON OTHER FRONTS

**New technology**

5.19 The Agency has the dual task of promoting research activities that lead to the more efficient utilisation of spectrum and of assessing the implications (in terms of interference potential, compatibility, occupied bandwidths etc) of introducing new technologies, in most cases alongside existing technology. The growth in digital technologies and their application to telecommunications and broadcast uses, coupled with alternative modulation and access techniques, has had, and will continue to have, a profound effect on spectrum utilisation.

5.20 Research carried out by RA includes assessment of the degree of compatibility of technologies, such as digital audio broadcasting, spread spectrum offering code division multiple access, and digital paging, through the use of 'frequency agile system simulators' capable of emulating the very complex emission structures being evolved. The Agency's facilities offer the ability to analyse efficiency and potential compatibility problems at an early stage and to propose corrections to any deficiencies that exist.

5.21 Work on establishing protection ratios led to the possibility of reducing channel spacing for private mobile radio licensees from 12.5 kHz to 5 kHz. As a result, the RA offered in August 1993 to consider applications from new and existing operators to take up the 5 kHz channel option using equipment meeting the new specification. This development should ease congestion in the private mobile radio bands, making room for future applicants and reducing the need for imposing channel sharing.

### Investment by the RA

5.22 The importance of investment by the RA in modern spectrum management tools was emphasised by the Stage 2 and Stage 3 Reviews. The RA inherited from its predecessors a mixture of databases and computerised planning and assignment aids developed on an ad hoc basis over the years. They were designed to meet immediate needs in particular areas with little opportunity for integration. The Agency has no master database of spectrum assignments.

5.23 Recognising the deficiencies in its computer facilities and in the availability of certain information, the RA has, since becoming an Agency, considerably increased expenditure on computer aided techniques for more effective spectrum assignment. The Agency is putting in hand a series of automation measures designed to facilitate creation of frequency allocation and assignment databases and to modernise both the administrative and technical aspects of spectrum management. These will be introduced over a period, as resources allow. The Agency has developed a comprehensive strategy to integrate its information systems.

5.24 As part of this modernisation programme, installation of a new system for spectrum management in the millimetric wavebands for terrestrial fixed links is now well advanced. Work has also begun on a new technical assignment and administrative licence computer facility for mobile radio. The intention is that the technical assignment system will engineer channels in such a way that the maximum loading can be achieved on the channel while maintaining the grade of service (e.g. time taken to gain access to a channel) required by the licensee. This should improve the quality of service available to customers, particularly in areas currently experiencing high traffic density.

5.25 Advanced computer-aided techniques are also being developed to replace the present semi-manual assignments system for licensing of sound broadcasting restricted service licences. This is expected to increase the capacity for accommodating these operations, which represent very efficient use of spectrum because temporary low power services can be assigned frequencies which are being held in reserve for planned permanent broadcasting stations. Such services are used for covering local events or charitable initiatives and are becoming increasingly popular.

### Public access to databases

5.26 As the Agency's databases and spectrum management tools improve, it will be possible to consider a greater degree of access to them by interest groups or individual licensees, to assist their own forward planning. Currently, the RA is not free to disclose details of individual licences or frequency assignments in a way which could allow licensees to be identified, without the risk of a breach of confidentiality between licensees and the Agency. Data protection issues are also involved, but the Government proposes to encourage the RA to develop plans for greater access within the law, as soon as resources allow.

**5.27 The Government would welcome views on the desirability of more open access to the RA's databases, and on what types of information would be of most interest to radio users.**

## CONCLUSIONS

5.28 The Government considers that the steps described in this chapter have made a significant contribution towards more efficient spectrum management but now need to be accelerated. Th Government intends to ensure that this happen However, there are two important areas where p sent legislation limits further progress. These dealt with in the next two chapters.

# CHAPTER 6
# PRICING

6.1 More radical steps beyond the present system of spectrum management would require new primary legislation to change the current licensing and pricing regime for the radio spectrum. This and the next chapter describe the current pricing system and outline two possible models for more effective use of pricing policy to help the task of spectrum management in the face of growing demand and expected increases in congestion.

6.2 The classic method of efficiently allocating any scarce economic resource is through the price mechanism. Yet spectrum managers are currently largely denied this tool in the vast majority of countries.[9] In the UK, the RA is empowered only to charge licensees sufficient to cover its costs and is therefore unable to use pricing policy as a tool of spectrum management. Within the constraints of existing legislation, the RA charges certain fees on a per channel or per band basis, which may encourage licensees to occupy only as much spectrum as they actually need. But, under present legislation, the fees charged cannot and do not fully reflect the scarcity value of the spectrum.

6.3 The current inability to employ a price mechanism to influence radio use has a number of disadvantages. First, it provides little inducement for licensees to shed spectrum surplus to their immediate needs. Holding on to seldom or underused frequency bands only incurs the relatively low cost of the licence fee. Licensees are unable either to realise the value of the spectrum they occupy by selling surplus spectrum, or to buy access to more. Second, there is no market signal steering users to less congested frequencies. Third, the incentive for manufacturers to develop and operators to use more spectrum-efficient technologies is blunted.

6.4 If spectrum is to be distributed more efficiently among existing user groups and providers of new services, radio users need more incentive to occupy less spectrum, to use the less congested areas where possible, and to invest in improved techniques and equipment. The Government wants to explore whether, in addition to all the other developments discussed in this document, this incentive might be strengthened by legislation to change the pricing system.

6.5 The purpose of introducing a new pricing system would be to influence choices made by spectrum users so that:

- their applications for spectrum access would reflect the value they place on their spectrum use;
- applicants would consider alternative means of communication, not necessarily requiring access to the radio spectrum, and avoid use of the most congested frequencies;
- existing users would examine their spectrum needs and shed surplus spectrum;
- new entrants and new technologies would have a greater chance of gaining access to the spectrum.

6.6 Any new policy on pricing for the use of the spectrum must take account of other policies intended to promote a healthy economy. It must also ensure that radio can continue to be used as a business aid by companies of all sizes and must recognise the importance to the country of many scientific, social and entertainment services which use radio. At the same time, there must be safeguards to ensure that the monopoly control of spectrum access is not exploited and that the new pricing system does not act as a barrier to entry for smaller users.

**Timing**

6.7 Following the period of debate which the Government hopes will result from publication of this document, the Government will decide whether to lay legislation before Parliament. Subject to Parliament's views, it would be the Government's intention that any legislation would provide for a transition period for introduction of a new pricing system to enable current and potential licensees to adjust to the new system.

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[9] For recent developments in Australia, New Zealand and other countries, see Annex A and later paragraphs in this chapter and chapter 7.

### Scope of new system

6.8 The Government envisages that any new system would be introduced by stages in different parts of the radio spectrum. The most obvious places to start would be where congestion is most evident. The Stage 2 Spectrum Review recommended that "if, despite efficient spectrum management, frequency bands available for assignment to fixed links approach congestion, a substantial addition to the annual licence fee for assignments in these bands should be considered, to reflect the opportunity cost of using radio and to encourage the use of cable". The Review Committee was referring to the bands above 3.4 GHz covered by its review. But it could well be that bands below 3.4 GHz, allocated to fixed, mobile or other services, would also benefit in spectrum management terms from a new pricing system. This could be the case both for the administratively decided pricing criteria recommended by the Committee and described in the next section, and for the market system outlined in Chapter 7. However, the Stage 3 Review was doubtful about the benefits of spectrum pricing for the 28-470 MHz bands.

### Public Sector Users

6.9 Public sector users currently pay charges for radio use in the same way as private users. In the interests of equity and of efficient spectrum use, the intention is that, under any changed pricing system, the Government would pay rates for spectrum use comparable to those for non-Government users. The essential spectrum needs of the defence forces and the emergency services, such as police, fire and ambulance services, would need to be protected, perhaps by applying special arrangements to safeguard their spectrum holdings. It would be necessary to ensure that the spectrum pricing system did not have the effect of reducing these users' access to sufficient radio spectrum, or the volume of their operations.

### Experience in other countries

6.10 A number of other countries have been considering a move to a more market-based pricing regime. Annex A describes the current situation in Australia, Canada, Germany, Japan, New Zealand and the United States of America. Canada, Germany and Japan have decided to make no radical moves in the near future, but in New Zealand, significant areas of spectrum are now subject to auction procedures. Australia has moved to a mixed market system: in July 1993, a new Act introduced a comprehensive set of reforms involving pricing based on market principles (including use of auctions in selected bands) and the creation of a Spectrum Management Agency modelled to some extent on the RA in the UK, together with a number of administrative reforms designed to improve the spectrum management process.

6.11 These developments are instructive, as also are the measures recently adopted in the United States for introducing more market-based management methods, including possible use within the next year of spectrum auctions for 200 MHz of spectrum to be released to civil users from federal government use and for spectrum for PCS (Personal Communications Services). It should be noted, however, that in radio terms the UK is in a different situation from all these countries. It is surrounded by a number of near neighbours whose radio systems have an interference potential over virtually the whole UK land mass (and vice versa). It also lacks the size of the United States or o Australia, limiting the potential for spectrum re use or resale on a geographical basis.

### EC Implications

6.12 Greater efficiency in spectrum managem is in the interests of Europe as a whole. It remain necessary to ensure that arrangements i UK do not hinder progress towards harmonis of European frequency use where appropri determining the scale and scope of any refo the UK, the effects of new pricing methods o market for radio equipment in the UK and on i Community trade will have to be taken i account. For instance, high licence fees charged network operators or to users of particular kinds o equipment could place UK firms at a competitive disadvantage compared with their continental or world competitors. Equally, exports to the UK of equipment tunable only to particular frequencies could be hindered by high licence fees for the bands used by that equipment, or even by non-availability of licences. In the extreme, neither situation would be acceptable to the UK or to its trading partners, and could raise legal issues. On the other hand, more intensive use of the spectrum - the ultimate goal - would increase the size of the UK market.

6.13 Recent studies carried out for the Commission have recommended further work at the European level on the role of the price mechanism in spectrum management. In any decisions on changes to the pricing regime in the UK and in other EC countries, it will clearly be important to take account of the European dimension.

### What would happen to additional revenue generated?

6.14 Any movement away from the present system of charging fees to cover costs is likely to result in revenues in excess of cost accruing in the first instance to the spectrum management authority, raising the question of how those additional revenues might be used.

6.15 As an Executive Agency, the RA has a Corporate Plan approved annually by Ministers and setting out its business plans for a five year period. These may include plans for higher levels of investment in improved spectrum management tools, engineering effort, research, enforcement activities or any other area of activity the Agency believes should be expanded in response to demands made on it by radio users and manufacturers and in the interests of providing a better service to its customers. The Agency is encouraged by Ministers to put forward plans for use of appropriate resources, subject to meeting strict performance targets. The means therefore exist for the Agency to use part of any extra revenues for investment purposes, to the extent Ministers judge appropriate.

6.16 Beyond that, any further revenues generated by new pricing methods applied by the RA would be returned to the Exchequer for the benefit of the general taxpayer, reflecting the perception of the radio spectrum as a natural resource of potential benefit to the whole community. If some of the RA's spectrum management functions were privatised and separate spectrum management organisations set up (Chapter 7), legislative provision might have to be made to counter excessive profit-making.

## POSSIBLE OPTIONS FOR CHANGE

6.17 There are two main options for change from the existing spectrum management system to make use of new pricing mechanisms. Both would require legislation. The first would consist of:

- the existing organisational arrangements, with the RA retaining a central role; and
- new ways of fixing prices for spectrum use administratively.

Within this option, there would also be scope for further devolution of certain aspects of spectrum management activity. Development of a secondary market in licences (see Chapter 7) might also be possible.

6.18 The second, more radical, model could involve one or more of:

- a change from the existing equipment licences to a different form of spectrum access right, amounting to a spectrum "lease";
- auction of management rights to private sector SMOs. These would provide frequency planning services and make assignments on a commercial basis. Transfer of management rights could also be by a "beauty contest" selection mechanism, or by Government appointment, for a fee. In practice, this would amount to privatisation of some of the spectrum management tasks currently performed by the RA;
- direct auctions by the RA of selected areas of spectrum.
- a secondary market in spectrum access rights

6.19 Carried to the extreme, both the direct auction and SMO routes effectively privatise those functions of the RA which could be performed outside the public sector, leaving a core of regulatory functions which only Government can undertake. This model is considered in Chapters 7 and 8. The first model is described in the following paragraphs.

### General considerations

6.20 Pricing criteria would be intended to facilitate the operation of a more flexible and effective spectrum management system. If the Government were to adopt a form of spectrum pricing leading to payment of higher licence fees for congested bands, the intention would be that users - both new entrants and incumbents - should be faced with more sharply focused economic choices than before between alternative courses: for example, whether to pay higher fees to use a more congested but technically easier to use band; or lower fees to move to a higher band (where greater bandwidth may be available); or to invest in more efficient equipment to enable them to use less spectrum in the lower band and incur reduced fees.

6.21 The Government recognises that differential pricing would only be likely to influence decisions by existing users if the amortised cost of re-equipping for different bands is less than the accumulated increase in licence fees in their previously assigned band over the same period. For differential pricing to be effective in relieving congestion by releasing under-used spectrum or encouraging movement between bands, the Government might have to consider the need for giving assurances on the level of fees to be charged in the future in the bands to which users decide to move.

6.22 Careful consideration would have to be given to the position of services able, for technical reasons, to use only the band in which they are presently sited, particularly if reduction of bandwidth is not currently a technically viable option. The status of licence-exempt services which pay no licence fee would also have to be resolved. This is not a significant issue for the low power devices currently exempted, but could have competitive implications for new services such as DECT (European Digital Cordless Telephone), which will be a licence-exempt service.

6.23 Under any new fees system, the expectation is that periodic Fees Orders listing revised fees would probably still be made, subject to approval by Parliament. If the RA continued in much its present form with similar responsibilities, part of the fees would still be needed to cover its operating costs.

6.24 Possible options for changing the administrative pricing system are discussed in the next section. Although their detailed nature points to the desirability of a wide enabling power to be given in new legislation, the Government considers it important that any new pricing system should be stable, transparent and easy to understand. Prospective and current users should have access to information telling them clearly the likely costs to them of particular kinds of spectrum use in a particular location and with particular technical parameters. Manufacturers will also need access to this information to enable them to assess potential demand for types of system designed for use in particular frequency ranges. To have the desired impact on spectrum use, any changes to the current system would have to be accompanied by an information campaign to enable the radio industry to make informed decisions about communications requirements.

### Possible ways of fixing fees administratively

6.25 Charges would have to be at least sufficient to cover the full costs of administering each licence type. There are several possible methods of charging differentially. These could involve charging according to one or more of a number of criteria, such as:

i) frequency band;

ii) amount of spectrum used, in MHz;

iii) channels or links used;

iv) degree of loading;

v) spectrum efficiency of equipment used;

vi) transmitter power/coverage area;

vii) geographical location.

#### i) Charging by frequency band

This could succeed in moving users to different or higher bands, or other services where there is a choice, only if the premium charged is higher than the increased equipment costs incurred by moving. Unless the difference in licence fee was very great, users might prefer to stay in their current assigned frequencies with their existing equipment, until such time as it needed replacing. The promise of lower licence charges might then induce them to consider a move.

One of the aims of pricing by this method would be to encourage users to seek equipment for use in particular bands. Full information on fees structures would have to be made available by dealers to customers to enable them to make informed choices. Pricing in this way might encourage users to move to more spectrally efficient technologies usable in bands where fee charges were relatively low. This in turn should increase the incentive for manufacturers to produce advanced equipment, while remaining in step with the increasing element of international standardisation in radio equipment.

This pricing method contains no incentive for the individual user to use assigned frequencies more efficiently and would only have an impact on spectrum use if users were able to move bands easily. Used together with a charge per MHz however (see (ii) below), it could have an effect on the amount of spectrum occupied by users in particular frequency ranges.

### ii) Charging by amount of spectrum used, in MHz

This method might help to persuade users to economise on their spectrum demands and to shed excess spectrum. But it would be more effective in influencing user decisions if used in conjunction with (i) and if the price differentials between spectrum ranges were large. An objective basis might be provided by charging the highest fees per MHz for the bands up to 1 GHz, for example, but with heavily congested bands such as VHF attracting a much higher charge than surrounding bands. If this succeeded in encouraging migration, the bands attracting a high per MHz charge might become less congested. On the other hand, these bands might then be financially unattractive to new entrants. This could lead to sub-optimum spectrum occupation if these prospective new entrants were prepared to use spectrum-efficient equipment when incumbents were not.

### iii) Charging by channels or links used

This is a method already employed by the Agency within licence categories such as cellular and trunked mobile radio systems for which the fees are calculated on a per channel basis. Fixed link services are charged on a per link basis with fees charged according to bandwidth and band. To encourage migration of fixed link operators to less congested higher bands, the differentials between bands would have to be sufficiently great to outweigh any costs arising from limits on link length and power at the alternative frequencies.

### iv) Charging by degree of loading

Intensity of spectrum use is already monitored by the Agency and used as a lever for promoting spectrum efficiency. Assignments are withdrawn from users who under-utilise their assigned frequencies. If loading criteria were to be used more intensively to encourage efficient spectrum use and discourage hoarding of underused frequencies, they would need to vary in different spectrum bands used for a range of purposes.

Under this pricing method, fees would decrease in proportion to degree of loading efficiency. There would be extra resource costs involved in monitoring and extra administrative work for the spectrum management authority if this option were pursued. The cost of monitoring must not be greater than the perceived advantages of enforcing loading criteria. The Government considers that this technique could be a useful adjunct to other suggested administrative charging methods, but should not be used in isolation as a charging criterion in its own right.

### v) Charging by efficiency of equipment used

Technologies offering the best frequency use tend initially to be expensive. Users with adequate access to the spectrum in their existing assignments have no incentive to invest in more efficient equipment. In contrast, radio operators with limited amounts of spectrum will make great efforts to develop more efficient spectrum techniques. Operators can be rewarded for their investment in equipment and techniques for making maximum use of the limited amount of spectrum assigned to them, by their ability to accommodate more paying subscribers or more traffic per channel. Typically, operators of smaller systems do not have a similar incentive to use more spectrum-efficient equipment.

If lower licence fees were charged to users of technologically advanced equipment meeting specified standards of spectrum efficiency, this might provide the necessary incentive. The corollary of this approach is that higher fees would be charged to users of less spectrum-efficient equipment. The equipment type could be entered on the licence application form by the prospective licensee. The fee differential between the more and less efficient equipment would have to be a realistic proportion of the cost of the new equipment, allowing for amortisation over a period.

If a charge per channel and/or per MHz and band were also introduced into the calculation of the total fee, the licensee would gain further advantage from changing equipment through payment of a lower charge for the reduced spectrum use achieved.

Administration of this approach would be complex and would involve keeping abreast of new equipment and its spectrum capabilities. To take account of rapid advances in equipment development, the differential charge for equipment would have to be reviewed periodically. Manufacturers, dealers, service providers and users would also need to keep in touch with developments, and to be aware of resultant fee changes which could affect their interests.

**vi) Charging by transmitter power/coverage area**

Under this and the following charging method (charging by geographical location), users requiring spectrum in areas of high spectrum use would be required to pay a premium.

Greater frequency re-use in some services, including PMR, could be obtained if operators were given an incentive to use the minimum transmitter power necessary for operation of their service. Fees would be calculated according to the degree of local congestion, the transmitter power and the area covered. Coverage could be tailored to the amount needed and measured against a geographical cell matrix of a kind made familiar by the cellular operators.

Provided that charges were set at sufficient levels, this method of setting charges administratively could be expected to achieve more efficient re-use of frequencies across the country.

**vii) Charging by geographical location**

Some administrations e.g. Canada and Australia, already charge differentially for private mobile radio use in city centres, in the suburbs and in rural areas. In France, the tariff structure for cellular radio networks sets a charge for high density urban areas twice that for low or medium density areas. Fees could be fine-tuned to reflect small geographical differences in spectrum demand, but at the cost of more complex administration.

The rationale for this approach is that higher fees for spectrum use in areas of high population density, and therefore of high spectrum use, may deter users who have other means of communication. In practice, administrations using this approach have found that differential fees have had little effect on demand.

6.26 Of the seven means outlined above, charging by band, by channels or links and by coverage area ((i), (iii) and (vi) respectively), are to some extent already employed in calculation of fees by the RA within the existing limits of confining income to the level of the RA's operating costs. Carrying these methods further under new legislative powers would be designed both to stimulate more effective and economic spectrum use, and to reflect trends in the spectrum marketplace. Some of these methods are complementary and could work together to meet the Government's aim o achieving more flexibility in radio spectrum ma agement.

**6.27 The Government would welcome c ments from existing and prospective r users on the desirability and possible effect spectrum demand of all these possible bases charging. In particular, it would welcome vie on whether they would have the desired resul of influencing radio users' choices between types of service or, indeed, whether to use radio at all.**

# CHAPTER 7
# MORE RADICAL OPTIONS FOR CHANGE

7.1 The second of the two models for possible change to the pricing mechanism of the existing spectrum management system would involve the creation of a system of tradeable property rights in spectrum. Options for radical change also include increasing commercialisation of the spectrum management function via growth of spectrum management organisations (SMOs) and the introduction of auctions designed to create a direct link between the use of spectrum and the value that users place upon it. The implications of these possible reforms are discussed in this chapter.

## The nature of rights to spectrum use

7.2 Like land, the spectrum is a finite resource and spectrum rights can be considered as analogous to plots of land in some respects. However, sub-dividing the spectrum into properties that owners can enjoy full unrestricted use of is more complicated than drawing lines on a map. Radio signals can cross geographical boundaries and cause interference. Moreover, they can interact to produce signals at different frequencies. Any system of spectrum management has to take account of the possible interference problems. The need for frequency coordination with other countries, as described in paragraph 4.12 and 4.13, must also be taken into account. One way to create spectrum rights would be to define them in terms of exclusive use of a particular frequency at a specified power within a geographical area, which would have to be large enough, having regard to the permitted transmitter power, to prevent interference. However, this would represent an uneconomical use of spectrum because, in practice, an efficient system of assignment must involve some users sharing frequencies.

7.3 A solution to the question of how to define rights to spectrum use would be to make provision for blocks of frequencies to be owned on an exclusive basis by lessors who would sub-let (assign frequencies) to users. Market forces at user level would operate through fixed-term rentals with fairly tight control by the lessor to ensure efficient usage and minimise interference levels. This model points towards exercise of management rights by SMOs, described later in this chapter, rather than the creation of fully sub-divisible spectrum rights at the user level. A management rights system would be potentially more flexible than giving exclusive rights to blocks of spectrum direct to the user: large block allocations in the fixed link sector, for example, have generally proved inefficient in terms of meeting overall spectrum access needs.

## Spectrum rights in Australia and New Zealand

7.4 In Australia, the Government has begun the process of introducing a class of "spectrum licences" which will give access to defined frequencies. These licences will be capable of sub-division, sub-leasing and amalgamation as well as sale on a secondary market; it is also intended that licensees will be able to take mortgages out on them. They will be introduced in bands where there is high demand for spectrum and where licensees are likely to be interested in creation of a market for spectrum. Existing licences in congested bands will be converted to spectrum licences on payment of a conversion fee; licensees unwilling to pay this fee will lose their assignment. The bands selected for the new system will be divided according to a spectrum plan and the corresponding spectrum licences sold by auction or tender, or "over the counter" at a price to cover the administrative costs of issuing the licence. This system will operate in parallel with an apparatus-based licensing system for less congested bands.

7.5 In New Zealand, the authorities changed the legal basis of treatment of the radio spectrum to accompany their auctions policy, creating a concept of management rights and subordinate licence rights over spectrum in place of the traditional concept (exemplified by the current UK legislation) of licensing the use of equipment under defined conditions.

## Rights conferred by licences

7.6 Practical experience of the recently introduced Australian reforms should indicate how far a radical reform of the legal basis of the rights conferred by radio licences (for example a change from licences to use equipment under defined conditions to some form of spectrum access right) is necessary to underpin the successful growth of a secondary market. In particular, a buyer in a secondary market will want some assurance of security of tenure in the asset being bought. Under current UK law, licences, even if issued for a fixed term, are liable to be revoked by the Secretary of State at his discretion. In practice, revocation is normally part of an enforcement procedure when licence conditions have been persistently infringed. But spectrum managers also from time to time exercise the option of giving warning of revocation of licences over a longer timescale, so that new services and technologies - sometimes Europe-wide - can be accommodated.

7.7 Establishment of an effective market will depend on the extent to which "owners" and prospective buyers of spectrum can be confident of their ability to exercise their rights of ownership, without interference by others. It may then be necessary to create a framework of law to uphold those rights. This is the basis of the New Zealand reforms (see Annex A).

**Secondary market**

7.8 The tradeability of the new Australian and New Zealand licences is an important innovation. At present, radio licences are not transferable in the UK.

7.9 The Government would like to explore whether a legislative change permitting a secondary market in rights conferred by licences would be beneficial in spectrum management terms. In principle, the ability to trade all or part of the rights conferred by a licence should create a strong incentive for the licensee to economise on spectrum use. It could also provide an additional means for new entrants to gain access to the spectrum. A secondary market could emerge with either the first (administrative pricing - Chapter 6) or second (auction - paragraphs 7.39-58) models for a new pricing regime.

7.10 For some services (for example where no limit is imposed on the number of licensees and the spectrum allocated to the service has no scarcity value), there would be little incentive for a secondary market to become established. It is also unlikely to develop for, for example, in some parts of the fixed link sector, where licence conditions may be highly tailored to suit the needs of the original applicant for communication between two fixed points. But this would not apply to the whole of the fixed sector; and, in the mobile sector, the possibilities offered by a secondary market seem likely to be attractive to users wanting quickly to dispose of spectrum or to acquire it. They may wish, for instance, to trade with their geographical neighbours so as to change their coverage area or capacity for mobiles.

7.11 Any transfer of rights conferred by licences would need to be registered with the spectrum management authority (currently the RA). In addition, any proposed change to licence conditions (other than the name of the licensee) would need to have no adverse interference effect and would normally have to be given specific approval by spectrum managers. Regulation of the secondary market would be necessary to prevent possible abuses.

**Growth of intermediary bodies**

7.12 A potential advantage from permitting a secondary market would be the growth of intermediary bodies able to offer a service to prospective seekers of licences. Such a service could be confined to a broking or consultancy role or could be extended to permit such bodies to hold licence rights and sell them to potential operators. In the latter case, there could be risks of "hoarding" and other inefficiencies identified below (paragraph 7.55) in relation to auctions. But, in principle, such intermediary bodies could prove helpful to the effective functioning of a secondary market. This role could also be performed by SMOS (paragraphs 7.20-27).

**7.13 The Government would welcome comments on the desirability in spectrum management terms of changing the legal basis of access to the spectrum and of permitting a secondary market in radio licences.**

## PRIVATISATION OPTIONS

**Overall management responsibility**

7.14 Before creating the RA in 1990, the Government considered whether the functions formerly performed by the Radiocommunications Division of the DTI should be privatised. At that stage it concluded they should not. Spectrum management can be seen as a continuum of functions, ranging from the negotiation of intergovernmental agreements on allocations and international coordination of assignments on a day-to-day basis, through detailed technical assignment of frequencies, to bulk administrative control of categories such as Citizens' Band and ships radio, which do not require individual technical assignment. As discussed in the next section, while private sector disciplines could improve efficiency at the management level close to the individual user, spectrum management at the top level of this continuum is essentially a regulatory function, to which licensing and extensive enforcement powers are attached.

7.15 In all countries, the body responsible for spectrum management is part of government. Indeed, under the present ITU constitution, only Governments may be members of the Union.

7.16 The conversion of the UK's principal spectrum management authority into an Executive Agency has aroused considerable interest in other countries and appears to have been used as a model by some. The creation of the RA seems to the Government to be starting to yield promising results in terms of importing private-sector type disciplines into the spectrum management process while retaining overall responsibility in the public sector. Encouragement of more private sector involvement in spectrum management would be a possible further step in the direction of commercialisation of parts of the spectrum management process. Changes to the current system of pricing for spectrum use would necessarily accompany the spread of private sector SMOs.

7.17 If, in the future, the Government were to decide that the functions performed by the RA had reached a sufficiently commercial stage for privatisation to be possible, a watchdog regulatory body (similar to OFTEL) might be needed to ensure that the privatised body did not abuse its monopoly power over the civil radio spectrum. If only part of the RA's functions were privatised, the regulatory body could be based on remaining parts of the current RA. However, progressive devolution of functions under either administrative or auction approaches to pricing could reduce the RA naturally to its core regulatory and supervisory functions. In the light of reactions to this document, the Government intends to analyse the range of privatisation options for spectrum management, as part of its considerations under its privatisation programme.

7.18 The next section considers whether it would be beneficial to introduce a stronger element of devolution into the management process by privatising more of the spectrum management functions below the overall management level which are currently carried out by the RA.

### Devolution of spectrum management

7.19 As noted in paragraphs 4.25 and 5.11-5.12, the RA already uses agents for distribution of more than half the radio licences issued annually. Under present law, the power to grant licences cannot be delegated by the Secretary of State. Contracting out is therefore confined to those cases where issuing a licence is a purely mechanical operation carried out under arrangements involving no exercise of discretion by the contractor. The Deregulation and Contracting Out Bill, now before Parliament, contains provisions which would widen the scope for contracting out licensing functions in the United Kingdom. Amateur and Citizen's Band radio licences, which do not involve technical assignment, are distributed under contract. There are plans to market test ship's radio licensing, another bulk licensing category which does not need detailed technical assignment. The only major licence categories still being directly assigned by the RA are in the private mobile radio and some of the fixed link bands, and broadcasting services. All of these require technical effort and expertise and cannot be contracted out for simple administrative processing.

7.20 The existing arrangements involving assignment of frequencies within a specific user group were described in Chapter 5 (paragraphs 5.11-12). All remain under the overall control of the RA. With a change in the law, a greater element of commercial incentive could be introduced at the assignment level by encouraging the setting up of a number of SMOs with management rights over certain spectrum blocks such as those used by PMR and fixed link services. Management rights could be obtained either at auction or by Government appointment. In the latter case, commission fees would be charged by Government and a regime put in place to ensure a fair return to both the SMO and the public purse.

7.21 SMOs would be empowered:

- to allocate use within the spectrum blocks covered by their management rights, subject to compliance with international agreements on UK uses of the spectrum concerned;

- to make assignments.

7.22 A similar system was proposed by CSP International in their 1987 Report (see paragraph 3.28 above), which recommended the introduction of commercial frequency planning organisations (FPOs) with delegated authority under spectrum management licences to decide the allocation of bands under their management to different services, as well as assigning spectrum to applicants. In practice, spectrum use in the UK is so constrained by international agreements that there would be very limited scope for such bodies to make their own allocation, as opposed to assignment, decisions.

7.23 A partially comparable system of this kind operates in the United States, where frequency coordination companies assign most fixed link and mobile radio frequencies on a quasi-commercial (some are non profit-making) basis, although the Stage 3 Review expressed doubts whether this is an appropriate regime for PMR in the UK. Each company is responsible for a specific block of spectrum and there is no real element of competition between the companies. Users pay fees both to the coordination company for recommending frequencies for their use, and to the Federal Communications Commission (the federal agency with responsibility for the civil radio spectrum in the USA) to cover the administrative costs of licence issue. Although not obliged to use these coordinators, most users are prepared to use their services because they operate comprehensive databases of frequency assignments and have expertise in the area of spectrum allocated for their use.

7.24 The Government accepts that a system of SMOs could lead to improved spectrum management at the assignment level. These bodies would need to possess specialist expertise to enable them to achieve greater user density in the bands allocated to them. They would have an incentive to make spectrum-efficient assignments, satisfying the spectrum needs of as many users as possible if they were permitted by the reforming legislation to charge an economic rent for the assignments they made or to auction them. They would charge fees for services performed for radio users, which could include consultancy services as well as assignment of frequencies. The new legislation would also have to provide for a regulator to ensure that SMOs did not abuse their market position. The RA would take on the necessary regulatory role.

7.25 The RA would act as a kind of wholesaler of spectrum, with the power to judge whether a particular organisation tendering for spectrum would add value to the retailing end of the operation. It would hand over block allocations to a SMO only if it was satisfied that the organisation met the necessary criterion of adding value to the process in terms of being able to apply specialist knowledge, enabling greater user density to be achieved in the allocated bands. Whether this model would be beneficial for all sectors will be judged in the light of the responses to this document. The Stage 3 Review indicated that PMR users would prefer assignments to continue to be handled by the RA.

7.26 Overseas experience has shown that, to be viable, organisations which assign frequencies to users on a commercial basis need management rights over significant blocks of spectrum. Long security of tenure over these blocks is needed to give potential management bodies an assurance that investment in technical and compute resources necessary for efficient spectrum use would be worthwhile. The Government would have to ensure that devolving such fixed term mar agement rights to the private sector did not limit ability to make any necessary adjustments at allocation level for accommodating new servic particularly those requiring agreement at the inte national level.

**7.27 The Government would welcome views on the merits of transferring further spectrum management functions to the private sector.**

## ENFORCEMENT

7.28 If the nature of the rights conferred by radio licences were changed in the direction of conferring a right of some kind over the spectrum itself, decisions would be needed on

a) the extent of protection rights against interference conferred by the licence. Great care needs to be taken that these rights do not produce excessive caution when spectrum assignments are made; and

b) how, and by whom, the necessary enforcement function should be carried out.

7.29 Interference to radio users takes two main forms:

a) interference by licensed users who, intentionally or unintentionally, exceed the limits of their licence by transmitting at too high a power level or at the wrong frequency or by over-deviation of the signal; and

b) interference caused by unlicensed users such as the pirate radio operators, who can and do cause disruption to the mobile frequencies used by the safety and emergency services as well as to domestic broadcast reception and business users of radio.

7.30 Limitation of interference relies on the vigilance of a spectrum monitoring and enforcement body. In the UK, this is part of the RA. Expectation of effective enforcement against both types of interferer would be likely to rise if users paid more for licences. Spectrum pricing could provide extra resources for more effective enforcement to the benefit of industry.

7.31 If radical changes were made to the existing spectrum management system, the Government would have to consider whether the enforcement function would be better managed by the spectrum management authority, operating where necessary through the courts, or whether licensees should generally be made to take on greater responsibility for solving their own interference problems.

7.32 Some interference complaints by domestic users, which used to be handled by the RA, are now dealt with by dealers in the first instance and are only investigated by the RA if no solution can be found. This provides a possible model for SMOs to do their own enforcement or interference correction work, calling on the RA, possibly on a repayment basis, to deal with the more difficult interference cases.

**An enforcement role for spectrum management organisations?**

7.33 If SMOs were set up, they could play a part in dealing with interference problems. For instance, they could monitor use of the spectrum within the bands they manage and might offer advice and a conciliation service to the parties to an interference dispute. In practice, this role would be limited to handling interference disputes within a SMO's own customer group or to a dispute involving one of its customers who is alleged to be interfering with the radio use of another user outside the group.

7.34 SMOs might be given the power ultimately to withdraw an assignment from a customer who persistently interfered with the radio use of others and refused to comply with the conditions of the licence or contract governing his assignment. However, this sanction would not be available against a radio user from outside its customer group.

7.35 Even if a range of SMOs provided assignment, consultancy and interference resolution services to large numbers of radio users, there would always be some radio users who would be outside their ambit. This points to the need for a central enforcement agency even in a revised spectrum management system. Such an agency, like the RA now, would act quickly to deal with interference caused, for example, to civil aviation channels or to the emergency services.

**Practice overseas**

7.36 The New Zealand system specifies in detail the degree of protection from interference conferred by licence rights, making potential licensees aware of the limitations on the rights they are acquiring. If necessary, they can take action in the courts if conciliation and arbitration procedures for settling interference disputes are not successful. Developments in New Zealand may provide useful empirical evidence of the results of introducing this type of arrangement, which effectively gives licensees the responsibility for resolving their own interference problems.

7.37 In the United States, frequency coordination companies advise the parties in interference disputes and attempt to ensure a solution is found to interference problems within their own customer group. If this fails, the parties concerned have to resort to litigation.

**7.38 The Government would welcome views on how enforcement might be tackled under a new regime and, in particular, on whether spectrum management organisations should have an enforcement role.**

## SPECTRUM AUCTIONS AND OTHER BIDDING PROCEDURES

7.39 In recent years, there has been much discussion, both internationally and within the UK, of the possibility of national administrations auctioning all or part of the radio spectrum used within national boundaries. Auctions could be used to let the radio user market - rather than the Government - choose who should have access to the radio spectrum and set its value.

7.40 Auctions could take a number of forms:

a) an open auction;

b) a written bid procedure where bidders are told what others have bid and are given the option of matching the highest bid within a time limit;

c) a closed bidding procedure;

d) a closed bidding procedure, but with the winning bid having to pay only the amount bid by the second highest bidder (the 'Vickrey' or second price auction procedure).

7.41 For any of these procedures, it would be desirable to set a reserve price and to lay down qualifying criteria for bidders. A version of option (b) is to be used in the new competitive bidding procedures for spectrum licences in Australia, where incumbent licensees will be invited to match the highest bid for the spectrum they currently occupy in congested bands if they wish to retain it. Option (d) was used in the first round of auctions in New Zealand but abandoned because of wide bid variations.

### Auction precedents

7.42 There is no direct UK precedent for an auction system for radio spectrum. The price mechanism provided under the Broadcasting Act 1990 was for allocation of national (not local) sound broadcasting franchises and regional television franchises (and the Channel 5 franchise), rather than for the spectrum allocation already identified for the services. A separate Wireless Telegraphy Act licence fee is paid by the broadcasters.

7.43 In New Zealand, auctions have taken place for cellular radio licences and for the UHF broadcasting bands. These have been successful in giving operators their desired right to operate communications systems, although some modifications to the auction mechanisms have since been found necessary (see Annex A for a description of the New Zealand spectrum management system). The New Zealand Government has carried out a review of its 1989 Radiocommunications Act in order to introduce amendments designed to improve its operation. Australia is implementing proposals which include the use of auctions in certain circumstances (see Annex A). Some other countries, notably Poland and Mexico, have raised revenue by auctioning cellular radio licences.

### Scope for use of auctions

7.44 Spectrum auctions could form part of a radical model for overhaul of the spectrum management system in the UK. The Governmen recognises that, whatever its knowledge of use requirements and demand pressures, it might b difficult to set prices (as discussed in Chapter 6) t reflect market signals or to influence user choice without a primary market in which prices set b auction act as a reference point.

7.45 In principle, the market is the best place deciding between alternative uses and u because those able to make the best use of sp trum will be prepared to pay the most for it. T market's freedom to decide how spectrum shou be used would be limited by internationally agree allocations and restricted to any alternative types of use permitted by international agreements within those allocations. It is not envisaged that broadcasters who bid for franchises (see paragraph 7.42) would also have to bid for spectrum rights. Within these limits, auctions could be introduced into the spectrum management system either by auctioning any blocks of spectrum which become vacant and for which there were competing potential uses or users, or (after suitable transitional procedures) by selling rights to already occupied bands.

7.46 There are several possible ways of employing auctions to distribute spectrum in either occupied or unoccupied bands. The two obvious routes are:

- auctions could be used by Government, acting through the RA, for selling management rights to SMOs for a fixed period;
- the Government could auction spectrum direct to users. This method could most readily be used to aid selection between several competitors for a band, cleared for introduction of a new service. This would be a development of the so-called beauty contest approach used, for example, for selecting the Personal Communications Networks (PCN) operators. It would have the merit of transparency.

**Unoccupied spectrum**

7.47 There are few areas of currently unoccupied spectrum. As shown in Figure 5, these are mainly in the higher frequency bands above 30 GHz. These bands have very great capacity but radio waves are carried for shorter distances than in the lower spectrum ranges and wide bandwidths are required. The RA has encouraged the development of fixed services, which can exploit this area of the spectrum and which have a large market. Even though a considerable increase in demand for fixed links is anticipated from the PCN and cellular operators in the future, competition for these bands on the open market could be expected to be limited.

7.48 In the lower spectrum bands, there is virtually no scope for a primary market in unused spectrum because these bands are already heavily occupied. Spectrum would have to be specially cleared for new services selected by an auction procedure.

**Occupied spectrum**

7.49 Auctions could also be used to sell occupied spectrum, though they would be clearly unsuitable in some areas. For instance, about 200,000 licences are on issue to UK hobby radio users such as Amateur radio enthusiasts and leisure yachtsmen. These licences do not confer any exclusive spectrum rights on their owners and their numbers are not limited by spectrum availability, so a market for them could not be created by direct auction.

7.50 While the same considerations do not apply to PMR services, the mode of operation of individual licensees (currently not far short of 30,000) would make it impractical to offer these licences at auction. The Stage 3 Review came to a similar conclusion. PMR assignments are made for use based on a station at a particular location, with a certain power level (and therefore coverage), and are planned to suit a specific operator's requirements, taking account of neighbouring operators and the need to avoid interference to other users. PMR spectrum would therefore be difficult to auction direct to individual users. Although there would not be a viable primary market for individual licences, a secondary market in individual licences might be feasible.

7.51 Nevertheless, PMR spectrum might be auctioned at a more aggregated level. This could be done by offering management rights for assignment of spectrum in PMR bands to intermediary spectrum management bodies. Their spectrum managers could then perform detailed and coherent planning for PMR in particular geographical areas, and make assignments accordingly. Auctioning might also be suitable for public access mobile radio (PAMR).

**Operation of an auction system**

7.52 Under either kind of auction system (auction of management rights to SMOs or direct auction of spectrum to users by the spectrum management authority, currently the RA), the successful bidder would pay both the price bid at auction and an annual fee to meet the administrative costs of the spectrum management authority. SMOs acting on a commercial basis could either charge a fee for assignments made by them or auction assignments to users.

7.53 If occupied spectrum were brought within an auction regime, the possible need for transitional arrangements for sitting tenants would have to be considered. They might, for instance, be permitted to pay fees on a sliding scale rising to market levels over a period of years. Economically efficient licence charges for existing users could be set at the market clearing price established at auction of comparable spectrum use rights. A key concern would be to avoid disadvantaging new market entrants, for example those using radio to achieve local network competition with the existing PTOs, through sudden changes in their basic cost structure.

7.54 Safeguards would have to be introduced to ensure that those with an essential need for access to the radio spectrum, such as the defence forces and the safety and emergency services, retained access to it. Under the new Australian system, access will be assured by reserving certain blocks of spectrum for such users. They will also benefit from being excluded from the requirement to pay market-related spectrum access prices for their licences, but will continue to pay apparatus licence fees.

### Competition policy issues

7.55 With an auction system, as with any new pricing system, the Government would have to consider how high entry prices would affect market entrants' ability to sustain a viable business, to compete effectively and to invest in advanced, spectrum-efficient equipment. Provision would have to be made to prevent potential abuse in the market place, such as the problem of possible hoarding of spectrum, and of major, financially powerful users acquiring spectrum to the exclusion of competitors or smaller players. Both of these practices would be detrimental to effective, intensive use of the spectrum and would require safeguards to prevent them. However, market pricing may reduce the risk of hoarding, since users would be more aware of the true value of their assigned spectrum and the cost of not putting it to best economic use. Equally, the establishment of a secondary market in spectrum under a system of management rights might open up the spectrum to new entrants. It seems possible that the introduction of a more radical market solution might in this way lead to greater flexibility, provided that there were sufficient safeguards to deal with anti-competitive behaviour.

### Other implications of auctions

7.56 In addition to the need to attach defined legal rights to spectrum blocks put up for auction, an important implication of an auction system is that bidders would want to have some assurance of reasonable length of tenure, perhaps in the form of a fixed term right. In the UK, the Government already accepts the importance of avoiding the imposition of changes in licence conditions as far as possible and recognizes the need of many operators for assurances of tenure, to the extent they can be given, to protect investment.

7.57 Further implications of auctioning spectrum would need to be considered. For instance, requirements for Europe-wide frequency allocations are multiplying. Under the current system, the Government is able to reclaim spectrum from occupants over a reasonable period of time, with due warning, so that spectrum can be made available within the UK to accommodate these new opportunities for spectrum use. Provision might therefore be needed for reclaiming auctioned spectrum so that Europe-wide developments in radio technology could continue to be exploited to the advantage of manufacturers, service operators and users. In keeping with its aim of promoting efficient spectrum use, the Government would also have to consider how to ensure that users maintained an adequate level of investment in new efficient equipment and methods in the later par of a fixed term franchise period.

**7.58 The Government would welcome viev from respondents on the potential usefulness auctions as a means of improving spec management.**

# CHAPTER 8
# A POSSIBLE OUTCOME

8.1 Previous chapters describe a wide range of possibilities. This chapter is provided to focus discussion and is even more subject to consultation than previous chapters. It indicates how a spectrum pricing system *might* work in practice and how such a system *might* develop in the light of experience. It also describes the organisational changes that might flow from a changed pricing system and how it could enable the private sector to increase its role in the assignment of spectrum, where this would benefit customers, and thus how spectrum pricing could lead to the privatisation of some of the licence assignment now carried out by the Radiocommunications Agency.

## Objectives of reform

8.2 The most crucial object of any reform will be to ensure a structure for spectrum pricing which:

a) promotes more *efficient* use of this scarce resource;

b) is demonstrably *non-discriminatory*, ensuring that spectrum can be made available to meet the user's need irrespective of the size or status of the applicant;

c) adds to the *value* which users derive from spectrum assigned to them.

8.3 Spectrum efficiency has three dimensions:

- technology improvement;
- geographical re-use;
- sharing by usage pattern.

Examples include:

- **technology:** the progressive reduction in the bandwidth required for individual Private Mobile Radio (PMR) channels. This has been reduced successively over the last twenty years from 50kHz to the current 12.5kHz. The Radiocommunications Agency approved in August 1993 new linear modulation technology to facilitate a further reduction to 5kHz;

- **re-use:** cellular network design. This permits re-use of the same pattern of assignments into progressively smaller 'cells', thus increasing capacity by carefully tailoring the coverage within each cell, micro-cell, pico-cell etc;

- **sharing:** use of access tones and access protocols to permit sharing of a single channel by multiple users. With appropriate safeguards, different classes of user with complementary patterns of usage can share a common channel.

8.4 A spectrum pricing system must give users an *adequate incentive* to seek improvements in *each of these three aspects* of spectrum efficiency.

## Pricing Structure and Procedure

8.5 Auctions or other bidding procedures could have a useful part to play in demonstrating the value individual users set on each area of the spectrum. However, they are cumbersome and, for a business trying to plan ahead, uncertain.

8.6 For most purposes therefore, the Government envisages that the price of spectrum could depend upon a sliding scale, published from time to time by the RA. This would enable a price to be calculated by intending spectrum users for a defined period ahead. The price could be based upon the parameters identified in Chapter 6 including:

a) the degree of congestion of the target band, (and thus the need for an incentive to use alternative, less congested bands);

b) the spectral efficiency of the equipment used, (and thus the incentive for technology improvement);

c) the transmitter power and geographic coverage, (and thus the incentive for geographic re-use);

d) the degree of loading (and thus the incentive to sharing by usage pattern).

**8.7 The Government would welcome comments on the factors that should enter into the setting of spectrum prices.**

8.8 However, in drawing up such a formula the RA would need to rely on the guidance of the market. This could be obtained through the selective use of auctions or other bidding procedures, as described below. The sliding scale outlined above could provide continuity; but the weighting given to its various elements could be reviewed at intervals in the light of values established through selective auctions and other market developments. Spectrum auctions could be of particular relevance for frequencies and locations where demand from competing users was particularly high.

**8.9 The Government invites comments on the use of competitive tendering procedures for the assignment of heavily oversubscribed rights to spectrum use.**

8.10 An important question is the level at which spectrum prices should be set. It is not the intention of the Government to use spectrum pricing as a means of taxation. But charges need to be sufficiently high to generate a real incentive for users to adopt more spectrally efficient technologies and network engineering, to move to less congested frequencies or to relinquish under-utilised spectrum. It is envisaged that charges would be set to the minimum necessary to generate the required market pressure. **The Government would welcome comments on the level of charges required to provide the necessary economic incentives.**

8.11 It is also envisaged that assignments that have been paid for could be tradeable or subject to sub-letting within their licence class to allow a secondary market to develop in response to demand.

### Contracting out spectrum assignment

8.12 Over the past ten years, the Radiocommunications Agency has been progressively contracting out the processes of issuing licences within fixed allocations. The Government considers that, wherever it offers benefits to the customer, this process of incremental privatisation should continue. Spectrum pricing and the privatisation of spectrum management are mutually supportive. Introduction of a spectrum pricing regime along the lines envisaged above would enable the process of progressive privatisation to be pursued further. Increasingly, the RA could then confine itself to a core of functions which can only be carried out within government; and private sector bodies could take over those of its functions that were capable of becoming transactions in the market place. Figure 6 illustrates this process: it shows the functions of spectrum management that:

a) have already been privatised;

b) could be privatised once a spectrum pricing system was in place;

c) form the core that would then remain in government.

8.13 The commercial approach adopted by the RA is already having its impact both upon sharpening its own goals and objectives and in enhancing quality and efficiency. This clarification of roles will facilitate the process of reaching objective decisions on the benefits of privatising specific functions.

8.14 The privatisation of spectrum assignments would require not only a satisfactory pricing system but also an agreed segmentation of the market within each licence class. This could reduce the need to exercise technical judgement on a case-by-case basis and codify technical assignment into agreed procedures. These could be embodied in assignment systems, which private sector bodies could acquire and use under licence.

8.15 A key development could be that of privat sector SMOs (paragraphs 7.20-7.27). There ar already a few such bodies in the UK. In the US there are somewhat similar bodies which exis greater numbers and play a much fuller role. S bodies could be well placed to add value improve efficiency for the benefit of spectr users. The role they could play would be dete mined in practice by:

a) their detailed knowledge of and contacts with their target group of spectrum users. One example is the Joint Radio Committee (JRC) for the fuel and power industries;

b) their efficiency, quality and cost of operation;

c) the price they paid for spectrum and the incentive this provided for them to maximise the

# Functions of the Radio Communications Agency

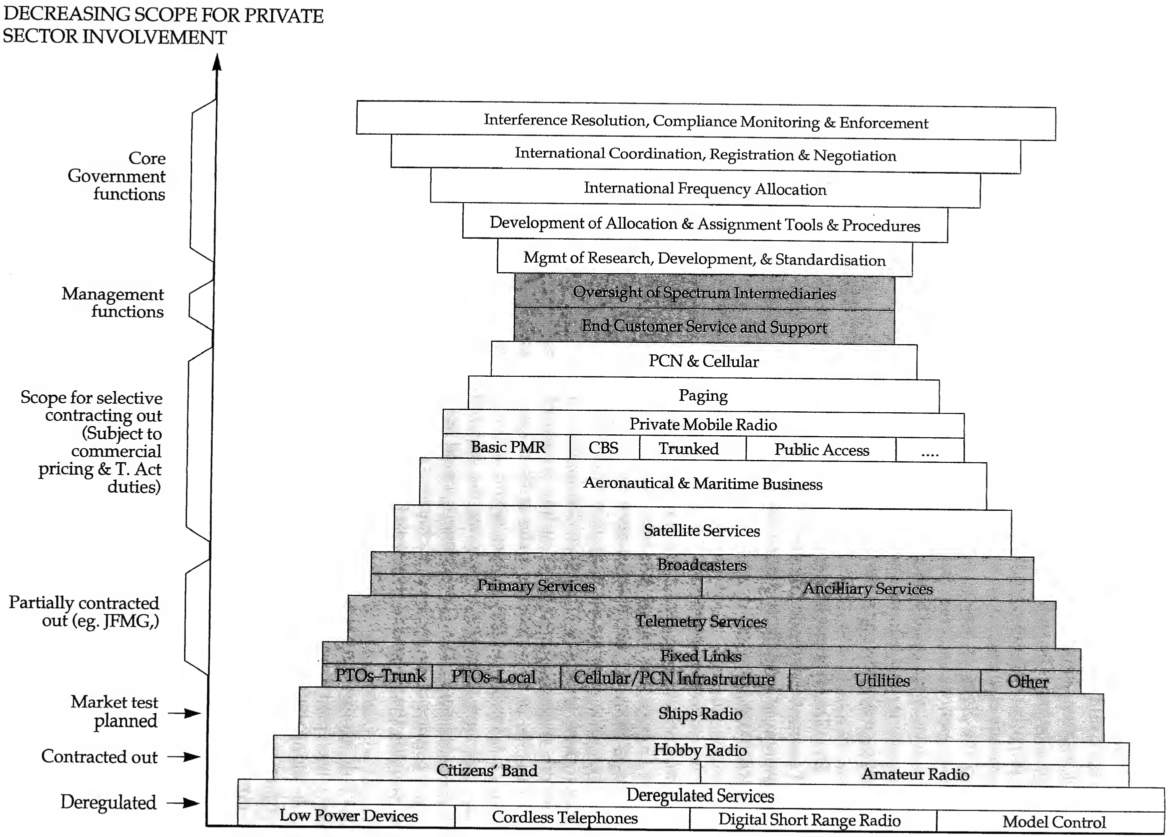
DECREASING SCOPE FOR PRIVATE SECTOR INVOLVEMENT
Core Government functions
Management functions
Scope for selective contracting out (Subject to commercial pricing & T. Act duties)
Partially contracted out (eg. JFMG,)
Market test planned
Contracted out
Deregulated
Interference Resolution, Compliance Monitoring & Enforcement
International Coordination, Registration & Negotiation
International Frequency Allocation
Development of Allocation & Assignment Tools & Procedures
Mgmt of Research, Development, & Standardisation
Oversight of Spectrum Intermediaries
End Customer Service and Support
PCN & Cellular
Paging
Private Mobile Radio
Basic PMR
CBS
Trunked
Public Access
....
Aeronautical & Maritime Business
Satellite Services
Broadcasters
Primary Services
Ancilliary Services
Telemetry Services
Fixed Links
PTOs–Trunk
PTOs–Local
Cellular/PCN Infrastructure
Utilities
Other
Ships Radio
Hobby Radio
Citizens' Band
Amateur Radio
Deregulated Services
Low Power Devices
Cordless Telephones
Digital Short Range Radio
Model Control

Figure 6

value from its use.

8.16 Such organisations might arise from either:

a) co-operative arrangements between users with a particular industry or sector focus (as in the case of the JRC); or

b) independent commercial operations where entrepreneurs perceive an opportunity to create value through technology, re-use or sharing in the ways described at the beginning of this chapter.

8.17 The RA could encourage the emergence of further SMOs by ensuring that spectrum was available to them on terms which made it attractive for them to maximise its value on behalf of their clients through improved technology, re-use or sharing. The RA would require SMOs to demonstrate their competence to exercise spectrum management functions and would set conditions for their operation. These conditions could include an obligation to maintain databases of spectrum usage to which public access would be guaranteed.

8.18 In effect, SMOs could have a role analogous to retailers, purchasing spectrum rights from the RA at a 'wholesale price' and selling them to clients at 'retail'. Where demand was sufficient, wholesale transactions by the RA could take the form of auctions or similar bidding procedures. SMOs would seek to maximise value on behalf of their clients and their success in doing so would be reflected in the wholesale prices they paid for their spectrum rights, which would be set at auction where demand was sufficient. In this way, value would be recaptured for the taxpayer.

8.19 In addition, SMOs might be expected to develop a monitoring and enforcement role within the class of users which they serviced. This could involve monitoring in pursuit of improved assignment efficiency and to check compliance with the terms of the spectrum rights. They could be charged with ensuring such compliance and could provide machinery for the resolution of disputes between customers. They could be entitled in the last resort to revoke rights where terms were persistently breached. They would not, however, be in a position to deal with the more general issues of interference and illegal use of spectrum. For example, it would not be appropriate for them to have powers of entry. Thus, for many enforcement activities, the RA would continue to bear ultimate responsibility.

**8.20 The Government would welcome comments on the scope for encouraging SMOs and on the role they could play.**

### Redefining the Radiocommunications Agency

8.21 The contracting out of further large areas of assignment to SMOs could leave the RA acting more often as a wholesaler and less often as a retailer of frequency assignments. The wholesaling functions would require it to:

a) manage wholesale allocations of spectrum to SMOs for retail distribution;

b) license and support spectrum management and assignment aids and techniques, facilitating progressive improvement in re-use and efficiency, both directly and through SMOs;

c) provide a point of escalation for customer problems and support where a SMO has been unable to resolve legitimate concerns.

8.22 This redefinition of its role could enable the RA progressively to confine itself to the core functions which must be maintained within government to ensure compliance with the UK' international obligations and to ensure fair acces to spectrum, together with the responsibility fo ensuring that the privatised market functione properly. These core functions could include:

a) meeting the UK's obligations on internatio spectrum management, coordination negotiation;

b) frequency allocation (ie between different uses, as distinct from different users) and establishing and maintaining the rules for assignment within allocation classes;

c) assignment at wholesale level to SMOs and similar bodies;

d) compliance, ensuring rules and the conditions attached to spectrum rights were enforced and conflicts resolved;

e) extending the scope of spectrum available for use as technology development continues and indicating the commercial potential.

**8.23 Comments are invited on the basic core of spectrum management functions that must be performed within Government.**

## CONCLUSIONS

8.24 The pricing framework set out above, further privatisation of spectrum management processes and rationalisation of core Government spectrum management functions, could help the Government to enhance customer choice within a framework which encourages economic efficiency; and to promote quality and value for money.

8.25 The Radiocommunications Agency, within an appropriate legislative framework, can provide the key facilitation role in the further growth of radio-based services. Some of the changes proposed in this document may enable this already strongly growing area of the UK economy to be further developed to the benefit of customers, manufacturers, suppliers, operators and service providers. **The Government would welcome comments on all the ideas for reform covered in this chapter.**

# ANNEX A

# RECENT SPECTRUM MANAGEMENT DEVELOPMENTS IN OTHER COUNTRIES

### Introduction

In recent years, many countries have been reviewing their spectrum management procedures. For some, like Australia and New Zealand, one of the driving forces behind proposals for change has been the need to update spectrum management to keep pace with reforms in telecommunications and broadcasting. Others, such as Poland and Mexico, have seen auctions as a means of raising much-needed revenue. But the overriding reason for these reviews has been concern about growing congestion in the spectrum, coupled with the perceived need to ensure that the spectrum is managed as effectively as possible.

The following pages describe the spectrum management systems in countries where:

- reviews have been carried out recently;
- reforms are proposed or have been carried out;
- the organisational structure for spectrum management bears some resemblance to that in the UK.

## AUSTRALIA

### Current system

1.1 The Australian Department of Transport and Communications (DTC) is responsible for managing the radio spectrum, with the exception of spectrum assigned for broadcasting which is managed by the Australian Broadcasting Authority. The DTC issues licences under the provisions of the Radiocommunications Act 1983. Apart from very low power applications, all spectrum users, including government and defence users, are licensed, with details held on a central database in Canberra. Licences are normally granted for 12 months.

1.2 Income from radiocommunications users is approximately double costs incurred in managing the spectrum; broadcasting revenue is about four times costs. Fees, set under tax legislation, are regarded as taxes paid by users in return for use of a scarce public resource owned by the community. They are updated each year in line with the consumer price index. Criteria used for fixing fees include: spectrum band, bandwidth, type of transmission, relative scarcity of spectrum and perceived commercial value to users. Higher fees are charged for:

- pmr and fixed links in the more congested geographical areas. Stations operating above 30 MHz pay one of four classes of fee, from extra high density (within 80 kms of the centre of Sydney), through very high (Melbourne and Brisbane) and high (Adelaide and Perth) to low density. Fees for fixed stations depend on occupied bandwidth and location;
- fixed links in the VHF and UHF bands, to encourage the movement of such uses to higher bands where demand is less;
- MDS, reflecting the expectation of high profits from such services when used for video entertainment and information purposes.

### Studies leading to proposed reforms

1.3 The possibility of granting property rights to spectrum users was explored at some length in the Bureau of Transport and Communications Economics (BTCE) publication "Management of the Radio Frequency Spectrum" (September 1990) (the BTCE is a centre for applied economic research which is formally attached to the DTC but independently conducts and reports on its research).

1.4 The BTCE proposed a market-based syste with creation of spectrum access rights (SARs its central feature. SARs for unoccupied bar would be auctioned. All existing assignmer would be automatically converted to SARs, which could be traded or leased.

1.5 In response to the BTCE report, the Australian House of Representatives' Standing

Committee on Transport, Communications and Infrastructure (HORSCOTCI) published a report "Management of the Radio Spectrum" in October 1991. This recommended the introduction of tradeable spectrum access rights in parallel with reforms to the administrative system and the establishment of a specialist spectrum management agency. It advocated gradual introduction of the new system, beginning with unused spectrum and bands subject to high demand. Rights would be granted on a fixed term basis, to help prevent possible anti-competitive behaviour and to give some assurance of a reasonable period for investment in equipment and infrastructure.

**Proposed reforms**

1.6 The Australian Government announced in September 1992 its acceptance of HORSCOTCI's recommendations. Instead of spectrum access rights (the SARs of the BTCE Report), the new tradeable licences are simply called spectrum licences.

1.7 The reforms have now been established in legislation and took effect on 1 July 1993. They have three main strands - a modified spectrum management system, departmental reorganisation (involving the formation of a Spectrum Management Agency (SMA) of the DTC) and the introduction of some new administrative procedures. The key features of the new spectrum management system will be:

- apparatus licences will be retained for some licence types;

- spectrum licences will grant access to the spectrum and will not normally be restricted to a particular use or equipment. Holders will be able to use a defined segment of the spectrum to transmit electromagnetic signals within a specified geographical area, not exceeding specified levels beyond the boundaries of that area;

- the Minister will designate frequency bands and geographical areas to be subject to spectrum licensing. There will be an embargo on further issue of apparatus licences in these bands;

- a competitive tender or auction process will normally be used to select spectrum licensees for unoccupied spectrum in designated bands only in parts of the spectrum where demand is high. A marketing plan for these bands will indicate the timetable for the sale of licences, the apportionment of spectrum between licences and the licences to be reserved for public and community services;

- where demand is low or auctions impractical, spectrum licences will be sold over the counter at a fee to cover the cost of producing and registering the licence;

- incumbent licensees in designated bands will be offered a spectrum licence based on the parameters of their existing apparatus licence, subject to payment of a conversion fee;

- the spectrum licence will be defined by reference to frequencies occupied, geographical coverage and length of fixed term. The parameters of spectrum licences will not include interference limits. To enable sources of interference to be identified, licensees will be required to register (but not acquire approval for) the technical parameters such as transmitter locations, power levels, modulation techniques and antenna configuration. The onus will be on spectrum licensees to resolve interference disputes between themselves as far as possible. The SMA will make available a conciliation and arbitration service;

- spectrum licensees will be able to change use of their spectrum (subject to international agreements), vary technical and other parameters such as equipment and power levels within the terms of their licence, amalgamate and subdivide spectrum licences and mortgage them. They will also be able to trade and sublet spectrum licences.

1.8 Other important features of the system include:

- a public register of all spectrum and apparatus licences will hold information on the type of spectrum access permitted, the licence holder, equipment details and licence conditions;

- planning changes will be certified by independent, accredited professionals;

- the provisions of the Trade Practices Act 1974 will be applied to buying and trading spectrum licences (as a restraint on hoarding or other restrictive practices);

- the Government will be able to take back spectrum licences from users, with payment of suitable compensation for loss of spectrum access before expiry;

- there will be no automatic right of renewal at the end of a spectrum licence fixed term of up to 10 years. The intention is that spectrum should be resold at the end of the licence term, with no presumption that the incumbent will regain it;

- before the end of a licence term, expressions of interest in the spectrum covered by the licence will be sought. A new marketing plan will be prepared by the SMA, and spectrum licences will be offered for sale to existing licence holders, re-auction or sale over-the-counter;

- the new system will not be applied to the broadcasting bands.

### Non-commercial users

1.9 Non-commercial spectrum users' interests will be safeguarded by express recognition, in the SMA's objectives, of the need for adequate provision of spectrum for public and community services; by the SMA's power to zone spectrum for exclusive use by these services; and by its ability to reserve spectrum licences for sale to them at concessionary rates. This means that:

- organisations with activities relating solely to safety of life and emergency services and which are currently licence fee exempt will be exempt from paying the access price for a spectrum licence;

- Government organisations operating on a quasi-commercial basis will have to pay market prices for spectrum licences. Those that are budget-funded will pay the full access price amortised over the period of the licence, but will have spectrum reserved for their use;

- community organisations funded primarily by voluntary contributions will be offered spectrum licences at concessionary rates.

### Review of administrative licensing and pricing

1.10 Following the establishment of the new Spectrum Management Authority (SMA) on 1 July 1993, a review the system of administrative licensing and pricing has been initiated. The majority of spectrum users are expected to remain under the existing administrative system of apparatus licensing for some time. One of the review's objectives will be to develop a system of charging which encourages the efficient use of spectrum but does not burden any user group unfairly.

1.11 Charges to be applied to spectrum use are:

- **access price** to be charged for spectrum licences, based on the value of the spectrum;

- **overhead charge** made annually to all apparatus and spectrum licensees, to cover the SMA's overhead costs;

- **service charge** for specific services provided by the SMA, based on cost recovery.

1.12 Planned reforms include increased monitoring of spectrum use, greater consultation with spectrum users, granting public access to the register of spectrum and apparatus licences and publishing clearer details of the licence fee structure. Consultative arrangements have been strengthened by formation of the Radiocommunications Consultative Council (RCC) of representatives of users and consumer groups, industry associations telecommunications operators and unions. This body will meet several times a year and set its own agenda.

# CANADA

### Current system

2.1 Under the Department of Communications Act and the Radiocommunication Act, the Minister of Communications is responsible for developing national policies for use of the radio spectrum and for ensuring its effective management in the public interest. In mid-1993, in a major revision of the structure of the federal government, the Department of Communications (along with 15 other departments and agencies) was dissolved and its spectrum management functions assumed by a new Department of Industry and Science.

2.2 All licensed users pay fees. Government and emergency service users pay at the same fee rates as other users. Fees are due for payment on 31 March each year: applications made in preceding months are charged pro rata. Renewal fees are charged at a lower rate than initial application or amendment fees to reflect the fact that work on, for example, coordination and interference studies is not needed for renewals. Total non-broadcasting annual licence fee revenues are currently just over $100 million dollars which more than covers the costs of managing the non-broadcasting spectrum including all appropriate overheads.

2.3 Fees for fixed links are on a bandwidth basis. A geographical zoning system is used for setting private mobile radio fees: users pay more in cities than in rural areas. This does not take into account the economic value of the spectrum and appears to provide little incentive for efficient spectrum use. Demand remains high in the congested city areas. Canada has 186,000 licensed PMR users (mobiles rather than base stations) and two national cellular networks - Cantel and a consortium of telephone companies, which operate their businesses provincially but cooperate on interprovincial networks and revenue sharing as though they were one network.

2.4 The Canadians have a system of public consultation for proposed changes to policies, allocations, licensing, standards and procedures in the spectrum management system.

2.5 Assignment is generally on a first-come, first-served basis. An administrative comparative process is used for selecting licensees from a number of qualified applicants for a limited amount of spectrum.

**Recent developments**

2.6 In September 1990, the Department of Communications issued a discussion paper "Towards a Spectrum Policy Framework for the Twenty-First Century". Comments on this and a policy proposal document issued in 1991 showed strong opposition among respondents to the use of auctions and lotteries for the allocation or assignment of spectrum. In September 1992, the DOC published a document "A Spectrum Policy Framework for Canada", setting out a series of policy guidelines for governing the DOC's future management of the radio spectrum. Among these were that the Government would:

- where appropriate, require the assessment of the availability of non-spectrum alternatives to spectrum -based services in congested areas. It will also promote the use of alternative non-spectrum technologies;

- continue to place emphasis on efficient spectrum utilisation and conservation techniques, if viable, as a requirement for existing and new services. Priority will be considered for technologies and systems which are more spectrum efficient;

- promote spectrum sharing while considering the impact on efficiency and operational requirements of services;

- consider setting "use it or lose it" licensing terms;

- continue to use the administrative comparative process where spectrum is in short supply or the number of new entrants has to be limited. It will only implement market-based approaches such as auctions or lotteries if they are thought to be in the public interest, and after full public consultation;

- develop radiocommunications research and development requirements in consultation with industry. This may include a financial commitment by certain radiocommunications public service providers as a condition of licensing or a portion of the licence fee.

# GERMANY

## Current system

### Organisation of spectrum management

3.1 Under the Telecommunication Installations Act of 1928 (revised 1989), responsibility for spectrum management in Germany is divided between the Ministry of Posts and Telecommunications and the Ministry of Defence who deal with civil and military uses respectively.

3.2 Until 1989, the Deutsche Bundespost (DBP) exercised, for civil use, the exclusive right of the Bund (Federation) to set up and operate radio installations. It therefore had a monopoly over spectrum for telecommunications without the need for any further administrative action. It operated as both regulator and operator, with a resultant theoretical conflict of interests. Since then, the Ministry of Posts and Telecommunica-tions has acted as regulator, with the public service operations of DBP split into three separate bodies reporting to the Minister: DBP Telekom, DBP Postdienst (Post Office) and DBP Postbank (Girobank). DBP Telekom exercises the monopoly of the Bund over the telephone service and transmission network.

3.3 The reform of 1989 also made provision for competition in telecommunications to be the rule, monopoly the exception. This has led to licensing of private network operators especially in the field of mobile telecommunications. The assignment of frquencies required, however, still remains the exclusive right of the Bund, exercised by the MOPT for civil use. DBP Telekom is responsible for providing telecommunication services and, under the Deutsche Bundespost Constitution Act, is entitled to be assigned the frequencies it needs for providing these services.

3.4 Also reporting to the Ministry are the Federal Approvals Office for Telecommunications, which deals with type approvals, and the Federal Office for Posts and Telecommunications, which oversees 55 District Offices and is charged with licensing, frequency co-ordination and registration, research and monitoring and deals with technical regulations and standardisation.

### Fees

3.5 Prior to 1989, radiocommunications fees accounted for less than 1% of the income of DBP. Following the break up of DBP's monopoly the amount of revenue generated has increased, although methods of further revising the system are being considered. The principal aim is to set fees to cover the administrative costs of frequency management. Fees set for, for example, microwave fixed links are now on a tiered basis. These fees are designed to encourage users to move to higher frequency bands. Fees for land mobile use are higher for urban than for rural areas.

### Frequency Assignment

3.6 Frequencies in the civil sector are assigned as follows:

- individual licences are issued to private radio users, for a fee;
- where larger frequency blocks are assigned to individual users for their own management (eg mobile trunked systems, GSM, satellite networks) a permit is issued under the Telecommunication Installations Act, for an operating fee;
- licences for security or emergency services are issued free of charge;
- where DBP Telekom is to be the user of the frequency, the frequency is assigned in the form of an official notification by the Minister.

3.7 Individual licences are normally issued by the Ministry's district offices on a first-come first-served basis.

3.8 The 28 concessions for trunk systems and one of the two GSM concessions were awarded by open tender for periods of 10 and 15 years respectively. About £20,000 was paid for each trunked system, which will be subject to annual fees o £2500 per channel.

### Problems with the current system

3.9 Most of the problems experienced by spec trum managers in Germany have historical roo Germany is constrained by geography. It is s rounded by nine countries, leaving only a v small geographical area where it has unlim national access to the spectrum and is not oblig to co-ordinate frequencies with any adjoinin country. It also has to take into account the demands of NATO.

3.10 Reunification has alleviated some of these difficulties, but has introduced others. Both parts of Germany used different duplex separations and channel spacings and had different uses for the same frequency bands. Networks are being installed and expanded in the new Bundeslander to conform to the operations in the new

Bundeslander. Now that most East European countries have joined CEPT, the border frequency problems may be resolved.

### Recent Developments

3.11 In 1989, a Frequency Regulation Committee was charged with the task of making recommendations for reform. Among the recommendations in the Committee's report, published in 1991, were:

- frequencies should be sold at a price determined by their scarcity value, as set by the laws of supply and demand. In future, a bidding procedure should be used where possible and appropriate;

- bidders would be subject to certain minimum requirements to ensure operational expertise and prevent speculation;

- the frequency authority should stipulate a minimum fee for tender, based on frequency management costs. The fee would be paid either as an initial lump sum or on an instalment basis;

- frequency use rights should be established on a fixed term basis;

- the market price established in bids for similar bands should be used as the basis for fees in bands not subject to market-related procedures. User fees should take account of the market value of spectrum use;

- broadcasters, safety of life services and other Government Departments, which have preferential treatment in the frequency allocation and assignment process, should not be required to bid for their spectrum use but should pay market-based fees;

- the Federal Minister of Posts and Telecommunications should appoint an independent body of experts to advise on regulation and help put the proposed reforms into practice.

3.12 Following the Committee's report, the Government is considering what form the reforms should take. By implementing reform in the spectrum management system, the Government hopes to achieve economically efficient use of the spectrum and to promote competition. Legislation would be needed to permit the market-related charging for frequencies where appropriate. The intention is to include in fees an element reflecting the market value of the assigned frequencies, in addition to an element covering administrative (including enforcement) costs. This would provide frequency managers with a direct means of intervening in the market. Sale or resale of frequencies by agencies other than the Ministry is not expected to be permitted for the foreseeable future.

## JAPAN

### Current System

4.1 Radio use in Japan is regulated under the Radio Law 1950. In 1952, the operational side of the Ministry of Telecommunications was made into a public corporation, the Nippon Telegraph and Telephone Public Corporation (NTT). Since 1953, international telecommunications services have been under a separate organisation, the KDD. The NTT has been the dominant player and has done its own planning, but has to make assignment proposals to the MPT. Proposed spectrum use has to be justified, and existing channels have to be fully loaded before further frequencies are made available.

4.2 The Ministry of Posts and Telecommunications (MPT) is responsible for all frequencies used for civil applications. The MPT carries out all frequency assignment work for both non-Government and Government use. It is responsible for decisions on the sub-division of frequency bands between the civil and military authorities. The MPT's Broadcasting Bureau and Planning and Policy Division are responsible for broadcasting and for planning, transmitter siting and research respectively. NHK, the public broadcasting authority, carries out research investiagtions for improvement and development of transmission and reception of broadcasting services. Under the Broadcast Law of Japan, the results of this research must be offered, as far as is practicable, for public use.

4.3 All radio systems, apart from certain low powered devices, are subject to licensing, generally for periods of five years. The MPT is obliged to license all applications, provided that they meet the licensing conditions and a frequency can be found. This is becoming increasingly difficult in the VHF and lower UHF bands which are becoming severely congested, even though there is only limited military use of the spectrum. The MPT's Radio Regulatory Bureau issues a licence only after carrying out a station inspection to ensure that the operating conditions specified in the pre-permit issued on application are being fulfilled.

4.4 MPT'S income is derived from three sources:

i) application fees (which accompany licence applications);

ii) inspection fees - radio transmission stations must be inspected by Government or a defined non profit-making body;

iii) tax revenue from central funds.

4.5 Several advisory councils report directly to the Minister. One of these, the Radio Regulatory Council, has five members appointed by the Minister with the consent of the House of Representatives and Councillors. It has wide powers and has to be consulted by the Minister on subjects such as modifications to the Radio Laws (there have been 37 amendments since 1950) and licence conditions and the more important individual frequency assignments, including all broadcasting stations of more than 100 watts.

## Spectrum use

4.6 Over the past five years radio use has almost doubled in Japan. Mobile radio, particularly cellular, has shown the steepest rise. There are 1.4 million cellular users in Japan out of a total of nearly 8 million radio users.

## Proposed reforms

4.7 The Radio Policy Panel, formed in September 1990 as an advisory body to the MPT, issued a report in 1991 noting that the rapid increase in the use of radio for a variety of purposes had led to frequency congestion, a growing frequency management and administrative workload and increased illegal use of radio. Recommendations made in the report included:

- re-assignment of frequencies for certain uses in order to accommodate growing demand;
- arrangement of infrastructure to facilitate spectrum use;
- development of spectrum technologies to support efficient use of radiowaves;
- introduction of an administrative computer system and database, introduction of a radio monitoring system to help deal with the sharp rise in unlicensed radio transmitters.

## Spectrum User Fees

4.8 As the considerable increase in administrative costs, including those of radio monitoring facilities and databases could not easily be funded out of central government revenues, the Government decided to introduce the spectrum user fee after studying the Panel's recommendation. The plan is to use the revenue from the spectrum user fees for the common benefit of all radio users. A surplus of revenue over costs in one year will be carried over to help meet costs to all users, for the following years.

4.9 In recent years spectrum use has expanded from public interest purposes to personal and industrial applications in the private sector. The Japanese Government therefore felt justified in moving from a system where general taxation paid for the administrative costs of spectrum management to one where costs are recouped from those who directly benefit from use of the radio spectrum.

4.10 Revenue from spectrum user fees wil used to cover the cost of monitoring, investi and enforcement and of constructing and taining a comprehensive database of ra tions.

4.11 The bill revising the 1950 Radio make provision for charging spectrum use was approved by the Diet in May 1992 to c into effect in April 1993. Its application has specified time limit. Changes to fees require future amendments to the Law.

4.12 Annual spectrum user fees have been set for nine different broad radio station categories defined on the basis of the type of communications and location of installation of radio equipment. The amount of the spectrum user fee for each category consists of two components. One component is the cost of monitoring divided equally among radio stations. The other is the cost of the database divided among stations according to the volume of information on items in the licence for each radio station registered in the database.

4.13 Government departments and local and regional public bodies dealing with fire and flood protection will be exempt from paying the spectrum user fee. Local and regional public bodies using radio equipment for disaster prevention will pay one half of the normal fee.

# NEW ZEALAND

5.1 The New Zealand system of spectrum management has recently undergone the most radical reforms of any in the world.

**General Background**

5.2 Following the enactment of the 1989 Radiocommunications Act, the New Zealand Government operates a dual licensing regime. Apparatus licences are still being issued to most types of licensee under the provisions of the 1987 Telecommunications Act, but, under the 1989 Act, the Ministry issues tenders under a new system of spectrum property rights, including both management and licence rights.

5.3 Frequency bands used predominantly for defence are managed by the Communications Division of the Ministry of Commerce (MOC) on behalf of the defence forces. Defence use of the spectrum is not subject to the new regime but other Government users have incumbent rights equivalent to those available to private sector operators. The Department of Defence and other Government users pay licence fees at the standard rate for all individual services.

5.4 Regional offices distribute CB, land mobile and many other kinds of apparatus licence but frequency assignment is done centrally. Land mobile licences are for base stations only. The MOC does not apply a scale of fees reflecting the number of mobiles which encourages users to pack as many mobiles as possible into the one frequency assignment. New Zealand is developing a terrain database prior to establishing management rights for land mobile services.

5.5 A 1988 report by NERA (National Economic Research Associates) formed the basis for the reforms. It recommended that both management rights and licence rights to spectrum should be tendered, allowing all incumbents to match the highest bidder.

**The new market system**

5.6 The main objectives of the introduction of the market system were:

- to carry forward the implementation of deregulation in telecommunications and broadcasting;
- to achieve an economically efficient means of managing spectrum.

5.7 The NZ Government has stated that it aims to:

- bring all radio spectrum progressively under the new regime. The Crown will continue to manage radio spectrum for services subject to international agreements and planning processes (such as maritime, aeronautical, radionavigation, radiolocation, satellite, amateur etc);
- allocate spectrum by competitive tender where demand exceeds supply;
- decide on the form in which rights are made available by taking account of the predominant existing use of the spectrum concerned, technical considerations and the form of expressions of interest made during public consultation;
- retain management of enough spectrum to meet social objectives (CB, Access Radio broadcasting, Maori language and culture).

**Management rights**

5.8 Management rights do not confer rights to make transmissions but the manager (owner) of a management right is able to issue licences (to himself or to others) for any frequency within the range of frequencies specified in the management right. Holders of management rights pay no annual fee. After paying for a management right via the tender process, the holder of a management right will only pay fees to the MOC if he issues a licence right to himself.

5.9 Management rights are registered and transferred on a basis similar to land ownership. They can be subdivided or aggregated to form smaller or larger blocks of spectrum or bands.

5.10 The MOC can:

- keep management rights as Crown property, issuing licence rights (normally by tender) and charging an annual management fee; or

- sell (ie privatise) the management rights. The holders can then either sell the management rights or sell licence rights.

5.11 The Crown's management rights are managed by the Secretary of Commerce (the Permanent Secretary of the MOC) on behalf of the Crown. So far, 4 management rights have been tendered for cellular and 10 for MDS spectrum. Licence rights have been tendered for UHF TV and AM and FM radio, for which the Crown has retained the 4 management rights.

**The tendering process**

5.12 Before the tendering process begins, the MOC asks for expressions of interest in the block of spectrum to be tendered. These blocks will generally be in areas of high demand, but spectrum tendered so far has been in unoccupied bands. The MOC determines the best way of dividing the band into lots for tender in the light of those expressions of interest and consults industry about the proposed division. The tender document lists the specific frequencies open to bids but does not designate the end use of the spectrum: the specified parameters of a management right effectively set limits on its range of uses.

5.13 Normal first price bidding is now used for tendering. Although soundly based in economic theory, second price bidding yielded varying bid amounts because of the small number of bidders for New Zealand frequencies.

5.14 After the winners in the bidding process have been identified, management rights are legally established by the Secretary of Commerce entering the rights in a register of rights. This is similar to a computerised land registry and holds details of the prices paid for spectrum "properties" and any mortgages held on them. All acquisitions of management rights must be cleared through the Commerce Commission (the NZ equivalent of the Monopolies and Mergers Commission) before they can be legally registered.

**Licence rights**

5.15 When management rights are created, existing apparatus licences in the band concerned are replaced with licence rights. Existing licensees operating the same kind of service in adjacent blocks are also converted to the new system. Most licence rights are valid for five years without further payment apart from an annual cost-covering fee paid to the MOC. Together with the fees from the apparatus licences still under the old system, these annual fees cover the spectrum management costs of the MOC. Existing assignments in broad casting and cellular bands are converted to 20 yea licence rights with the payment of fees limited t 50% of the amount paid under the competitive tender system by new entrants to similar unused frequencies.

5.16 While management rights are defined in terms of bands of contiguous frequencies on a national basis, licence rights are defined in terms of transmitter sites and equate to individual assignments. Licence rights prescribe parameters including frequency, transmitter power, transmitter location or area of operation, antenna height and polarisation, and tolerable interference limits. Transfer of ownership of a management right does not affect the validity of a subordinate licence right (comparable with change of ownership of a leasehold building). The expiry date specified for th licence right may be any date up to the expiry da of the management right.

5.17 The holder of a management right can i licence rights for the same frequency elsewhe New Zealand, maximising the potential use band. Licence rights can in theory be modifi operation at particular times of day, or one lic could be time shared under a normal civil con law arrangement. It is difficult to vary licen rights after tendering. Charges are made when certain variation thresholds are exceeded. If there are major variations above these thresholds, the rights are re-tendered. The engineering parameters of services (power levels, transmitter location etc) can be changed by negotiation in the marketplace but a new licence has to be issued and the change registered.

5.18 Land mobile radio use is still subject to the conventional licensing system (ie administrative licensing of radio equipment used for transmission) but the intention is to convert this category to the new system, when an active market in land mobile spectrum is predicted. There is some congestion in land mobile in the Auckland area but the MOC are opening up more bands to alleviate this. Otherwise, spectrum is plentiful.

**Interference limits**

5.19 Management rights are protected by adjacent frequency emission limits (AFELs) to define the strength of the signal permitted outside the bandwidth of the right and by protection limits, defining the protection which a manager may expect within his management right boundaries. Licence rights have unwanted emission limits (UELs) and maximum permitted interfering signal limits (MPISs). A defined floor level for noise (-50 dbW) is written into the legislation.

5.20 Under the earlier system, there were interference protection guarantees rather than coverage guarantees. Broadcasters had neither service area nor reception guarantees. To define the property rights, the Government establishes interference limits and transmission coverage areas. There are particular problems where there are secondary users of frequencies.

5.21 Management right holders are not responsible under the Act for ensuring interference limits are not exceeded by their licence right holders. The obligation is on the licence right holders to comply with the interference and unwanted transmission limits specified in their licences. Licence rights are legally enforceable. The Act provides for complainants to seek a remedy by giving notice to another rights holder before recourse to the courts. Conciliation and arbitration procedures are now being set up so that the courts can be treated as a last resort.

**Databases**

5.22 The Ministry of Commerce holds the National Frequency Register which is the database of Government (minus defence and police) and civil frequencies. The public have over-the-counter access to spectrum assignment information and to the information in the new register of rights. Once these two databases have been linked, private managers of particular sets of management rights will be able to search the entire usage of their region of the spectrum and gain access to related technical data.

**Trading of rights**

5.23 Both licence rights and management rights are tradeable. The theory is that once the system of management rights is in place, spectrum will be used for the most valuable possible purposes, and that band managers will trade licence rights between them to achieve this aim. Following the initial tenders, a small amount of trading has taken place. By March 1992, 6 AM sound radio licences had been transferred (one to the Crown) at prices from nil to £7,500, 27 FM sound broadcasting licences (three to the Crown) at nil to £95,000 and 14 UHF TV licences at £3,000 to £50,000.

**The system in practice**

5.24 The NZ Administration finds operation of twin regimes - spectrum rights/management rights and apparatus licences - difficult to administer, and confusing for customers. It is therefore keen to make progress with extending the new regime to as much of the spectrum as possible.

5.25 The new system was first applied in the broadcasting area, where the need for reform was greatest because of the time taken for comparative hearings used by the Broadcasting Tribunal for allocating rights for radio and TV broadcasting. The broadcasting tender process now takes months rather than years and many new stations have been accommodated without the need for potentially difficult administrative decisions.

5.26 Revenue from the auctions carried out so far has fallen short of the levels predicted in the NERA report. There have also been great differences in prices paid for similar concessions, apparently explained partly by the number of bidders. For instance, Bell South paid NZ$ 25.2 million for its cellular management right, while Telecom Cellular paid NZ$ 5,000 for an equivalent right.

5.27 Telecom NZ was unsuccessful in an appeal process over a Commerce Commission ruling against its bids for two management rights for cellular bands. The whole process from invitation to tender to appeal took three years but the time taken was less than that for administratively determining new television licences. All the other tenders resulted in quick assignments which were not rejected by the Commerce Commission. Because of various practical difficulties, the Government is reviewing the operation of the 1989 Act and plans to amend it.

5.28 A potential difficulty with the new regime appears to lie in definition of the property rights which lie at the heart of the system. It is difficult to establish legal rights, when parameters based on technical tolerances rather than rigid boundaries are the norm. The precise definition of parameters needed for licence rights may result in less efficient assignment of spectrum. This potential problem may be overcome when the commercial pressures of the marketplace encourage spectrum users to negotiate to overcome the rigidities of the legal definitions.

# THE UNITED STATES OF AMERICA

## Current practice

### Organisation of spectrum management

6.1 The principles in the Communications Act 1934 govern spectrum management in the United States. Administration of the radio spectrum is divided between the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA).

6.2 The Communications Act of 1934 created the FCC to regulate interstate and international commerce in communications by wire and radio and to execute and enforce the provisions of the 1934 Act. Among other responsibilities, the FCC regulates all private and commercial use of the radio spectrum, including broadcast and public telecommunications, as well as non-federal state and local government use and carries out international coordination for such use. The FCC, a regulatory body independent of the executive branch, is headed by five Commissioners, one of whom is designated Chairman. Within the FCC, the Office of Engineering and Technology of the FCC is responsible for allocation of the commercial and non-federal government spectrum regulated by the FCC. The FCC has four operating bureaux responsible for licensing decisions: Common Carrier, Mass Media, Private Radio and Field Operations. FCC procedures for allocation and licensing include opportunity for public comment.

6.3 The NTIA is an executive branch agency within the Department of Commerce. It is responsible for managing federal government uses of the spectrum, which are authorised but not licensed; for spectrum reviews; and for domestic and international telecommunications policies. It is advised on a wide range of spectrum management issues by the Inter-department Radio Advisory Committee (IRAC), which provides a link with the FCC. It also obtains advice from the private sector through its Spectrum Planning Advisory Committee. Unlike the FCC, the NTIA's procedures are not open to public scrutiny, but an annual report is published on the federal government's use of spectrum.

6.4 The State Department oversees the organisation of US delegations to international radio conferences.

### FCC budget and regulatory charges

6.5 The FCC's budget in fiscal year 1992 was $128.5 million. Under the law, the FCC prescribes and collects charges for certain regulatory services provided to the communications entities within its jurisdiction. These include charges for processing radio station licences and licence renewals and for other regulatory services related to use of the radio spectrum. Federal and public safety applications and applications for licences in the amateur radio service are not subject to a charge. The remitte charges do not go directly to the FCC as incom but are deposited in the general fund of the Treasury. In fiscal year 1992, the collec charges were $51 million.

### Allocation and assignment of spectrum

### Allocations

6.6 Nearly 60% of the spectrum below 30 GHz is shared between federal and non-federal uses. Non-federal exclusive uses occupy one third of this range.

6.7 The FCC procedures for allocating spectrum may be initiated by a proposal or petition put to the FCC or by the FCC itself. The FCC may proceed with a Notice of Proposed Rulemaking, setting out specific proposals and seeking public comment. Alternatively, if the proposal is not yet specifically defined, the FCC may choose to proceed first with a Notice of Inquiry. Where there are competing interests in spectrum, the FCC has to determine which use or uses will best serve the public interest. Technical considerations are weighed alongside public benefit factors. Finally, a Report and Order implements the decision. FCC decisions are appealable to the federal courts for review under established appeals procedures and standards.

6.8 In August 1993, President Clinton signed into law the Omnibus Budget Reconciliation Act 1993, which provides for the orderly transfer of frequencies, including frequencies that can be licensed using competitive bidding procedures, from the federal government to the FCC for allocation and assignment. The legislation requires the Secretary of Commerce to recommend for transfer at least 200 MHz below 5 GHz, with at least one half being located below 3 GHz. No more than half may be in the form of mixed (government and commercial) use bands. Within six months of enactment, the Secretary has to identify 50 MHz for immediate transfer. None of the 50 MHz can be for mixed use and at least one half of the 50 MHz has to be located below 3 GHz.

**Licensing and Assignments**

6.9 In the United States, it is usually the responsibility of prospective radio licensee to identify the frequency at which he wants to operate, to establish that it will not interfere with existing users and then to clear this proposal with the FCC. The FCC's licensing procedures vary by service, and may include selection of licensees by comparative application, competitive bidding or lottery.

6.10 The Omnibus Budget Reconciliation Act of 1993 grants authority to the FCC to employ competitive bidding procedures to choose among mutually exclusive applications to use spectrum frequencies. Specifically, the Act adds a new subsection (309j) to the Communications Act of 1934 to permit such competitive bidding on initial licence or new construction permits where the FCC determines that the service is principally one in which the licensee receives compensation from subscribers for the use of those frequencies. The legislation also amends subsection 309(i) to limit the use of random selection (lotteries) to those uses of spectrum that are not reasonably likely to involve the licensee receiving compensation from subscribers or to those applications that were accepted prior to 26 July 1993. The FCC's competitive bidding authority expires on 30 September 1998.

6.11 In authorising the use of competitive bidding, the US Congress directed the FCC to establish, for each class of licences or permits granted through the use of a competitive bidding system, methodologies that promote the purposes specified in Section 1 of the 1934 Act and the following objectives:

- to promote development and rapid deployment of new technologies for the benefit of the public including those residing in rural areas;

- to promote economic opportunity and competition;

- to ensure that these technologies are readily accessible by avoiding excessive concentration of licences and by disseminating licences among a wide variety of applicants, including small businesses, rural telephone companies and businesses owned by members of minority groups and women;

- to recover a portion of the value of the public spectrum resource made available for commercial use;

- to promote the efficient and intensive use of the spectrum.

6.12 The US Congress has directed the FCC to implement competitive bidding procedures by rulemaking within 210 days of enactment.

6.13 In addition, Congress has required the FCC to use competitive bidding to issue, within 5 years of enactment, licences and permits for a minimum of 10 MHz of the at least 200 MHz of spectrum located below 5 GHz that the NTIA is required to reassign from government use for allocation and assignment by the FCC.

### Frequency coordinators

6.14 Not all applications involve comparative consideration. For example, in the fixed link and mobile radio sectors, private sector frequency coordination bodies assist in the assignment process by recommending frequencies to users. A prospective user pays fees to a coordination company for frequency recommendations and to the FCC to cover the administrative costs of issuing the licence.

6.15 Frequency coordinators, each responsible for one or more of the major private land mobile service categories, are certified by the FCC to coordinate frequencies for most users in the private mobile radio bands. Users are obliged to apply for a frequency licence through the appropriate coordinator who charges a fee in addition to the FCC licence fee. Information on frequency assignments and licences is available in the public domain through computerised databases maintained by the FCC and the coordinators. As the frequency coordinators are each responsible for specific channels and blocks of spectrum there is no competition between them. The FCC prepared a Notice of Proposed Rulemaking seeking to introduce competition but the issues involved were found to be too difficult to pursue, at least for the time being.

6.16 In the private mobile radio sector, selection is generally on a first-come, first-served basis. There are currently over 17 million private mobile radio transmitters and 14 million paging subscribers.

6.17 In the fixed link sector, there are several major private sector coordination entities that provide a frequency planning service for the whole USA across all the bands allocated to fixed services. Smaller local agencies pay for access to the databases held by the main coordinators, and provide a local service. Users are not required to apply for licences through the fixed link coordinators, but are willing to use their coordination services because of their expertise and their comprehensive databases of frequency assignments.

6.18 Private companies also coordinate frequency use by satellite earth stations in bands shared by terrestrial microwave radio relay stations. They have extensive databases and have developed frequency management models.

### Sharing arrangenments

6.19 Prospective users are encouraged to negotiate sharing arrangements with existing users. In certain bands where spectrum availability is low, the FCC has authorised single channel private radio licensees to sell and transfer their licences to private carriers which provide spectrum access on a trunked basis. These arrangements can result in commercial benefits to both parties and achieve greater loading factors without increasing congestion.

### Comparative hearings and lotteries for cellular radio

6.20 For cellular radio, the FCC divided the United States into 743 market areas. The FCC allocated 40 MHz of spectrum to the cellular service, with 20 MHz to be made available to each of the two licensees selected in each of the 743 market areas. Subsequently, as cellular use expanded, the FCC allocated an additional 10 MHz of spectrum to the cellular service. One of the two initial licences in each market was competed among wireline carriers with a presence in the market area. Competition for the second initial licence was open to all other qualified applicants. Licensees were required to make the underlying cellular service available to resellers. For the first 30 markets, selection of the initial licensees was by comparative hearing procedure. For the remaining markets, the FCC used the lottery process to select the initial licensees. By 1992 there were over 11 million subscribers. Areas not yet served under existing licences will soon be offered under new application procedures.

### Proposed reforms

6.21 In December 1989, the NTIA issued a Notice of Enquiry announcing a comprehensive policy review of spectrum management. The NTIA's report on the results of the consultation, "US Spectrum Management Policy - an Agenda for the Future" described various spectrum management options including auctions, lotteries and administrative price-setting aimed at "revenue enhancement". Among the report's many conclusions and recommendations, some of which have now been implemented (see paragraphs 6.8 and 6.10-13) were:

- spectrum managers should introduce increased flexibility into the allocation system by encouraging more sharing between private and government users and increasing choices for users in the use of spectrum assigned to them;

- greater reliance on market principles in distributing spectrum, particularly at the assignment level, would be a better way to apportion spectrum than regulatory changes and block allocations;

- auctions should be used for assignment of new frequencies in certain cases, but not for "public interest" uses;

- the FCC should conduct an experiment in granting private sector users rights to transfer or sublease part of their spectrum to others. This might best be done for spectrum above 10 GHz, or spectrum reallocated from the federal government to private sector use;

- the NTIA and FCC should develop additional regulatory or economic incentives for the use of alternative technologies in congested portions of the spectrum;

- the NTIA should examine the possibility of setting up a fee system for federal government users to encourage greater efficiency among such users and to provide funds to improve management of federal spectrum;

- the NTIA should study the possibility of leasing spectrum from the federal government to private sector users;

- the FCC's computer databases should be expanded to include all data needed for frequency coordination, and the capability developed for using on-line access as a means of coordinating assignment requests, granting licences and updating the master file of frequency assignments. It should include both engineering and administrative functions;

- the scope should be considered for giving, for a fee, remote on-line access or access by read-only compact disc to unclassified databases, provided that relevant security problems can be resolved.

6.22 Under the FCC's private and mobile refarming proposals, the FCC hope to make better use of the spectrum available for mobile radio, with particular emphasis on channel splitting. Their proposals also offer scope for creating more exclusive (as opposed to shared) channels and for reserving some channels for advanced technology applications. The FCC have published a Notice of Proposed Rule-making (NPRM) on refarming; the resultant FCC Report and Order was expected to be published by early 1994.

# ANNEX B

# GLOSSARY

**Allocation**

a) The process of identifying specific frequency ranges for specific applications; or

b) a frequency band entered in a table of frequency allocations, for use by one or more terrestrial or space radiocommunications services, or the radioastronomy service, under specified conditions.

**Ancillary broadcasting services**
Radio services used in the production of programmes for broadcasting or other entertainment purposes. Such applications may be used to carry programme material (eg radio microphones or vision links) or control channels (eg instructions to camera crews).

**Assignment**
Authorisation given by a licensing authority for a radio station to use a specific radio frequency or channel under specified conditions.

**Attenuation of signals**
The reduction in strength of a radio signal, which may be due to atmospheric absorption, buildings etc.

**Bandwidth**
The range of frequencies occupied by radio signal or the range of frequencies over which a radio receiver operates.

**Cellular radio**
A mobile radio system - usually one providing public telephone services - in which the desired service area is divided into a number of sub areas (cells), the base stations of each cell generally being interconnected to provide continuity of communications from cell to cell.

**Civil use**
Use of the radio spectrum by non-military authorities; that is commercial and government use including broadcasting, police, fire and coastguard communications, etc.

**Common Base Stations**

a A single channel base station shared by all users (also known as a community repeater); or

b an installation, on a good site giving wide area coverage, under the control of one or more operators, offering mobile communications services on a commercial basis to a number of independent users.

**Decisions of the ERC**
Agreed Decisions, on the harmonisation of spectrum use or radio regulatory regimes, adopted by CEPT and which certain member countries are committed to implement.

**Duopoly Review**
The review by the UK Government of services provided by BT and Mercury Communications Limited following which the Government decided to issue licences to other operators to provide telecommunication services over fixed links, whether cable, radio or satellite.

**Electronic news gathering**
Television coverage of news events etc by means of television cameras (as opposed to film cameras) generally using equipment sufficiently lightweight to be carried by one or at most two operators, the signal being either recorded or transmitted via a radio link to a base station.

**Fixed link**
A communications link (generally by radio in the context of this document) between two specified fixed points. Such links may be uni-directional (eg carrying television programmes to a transmitter) or bi-directional (eg carrying telephone traffic).

**Frequency agile**
The ability of a radio system to shift rapidly from one frequency to another, usually to avoid interference or detection.

**Interference**
The effect of unwanted signals upon the reception of the wanted signal in a radio system, resulting in degradation of performance, mis-interpretation or loss of information compared with that which would have been received in the absence of the unwanted signal.

**Microwave frequencies**
A term used to signify radio frequencies at the higher end of the radio spectrum, generally above 1000 MHz (1 GHz).

**Military use**
Use of the radio spectrum by the armed forces, including the Ministry of Defence for their own internal communications, but excluding the emergency services such as police, fire, civil defence, etc.

**MVDS (Multipoint Video Distribution System)**
A system which uses microwave frequencies and techniques to distribute television programmes either to the general public or to cable television systems over a relatively small geographical area.

**Network operator**
The organisation licensed to operate a telecommunications network.

**Opportunity costs**
The returns from the use of the assets in the next best alternative.

**(Passive) space observation**
The observation of physical properties of the Earth and its environment by means of a radio receiver onboard a spacecraft. Typical applications include e measurement of ocean temperatures, soil oisture content etc by detecting radiation from e Earth.

**Personal Communications Network (PCN)**
A mobile telephone network using cellular radio designed specifically for hand-held portable terminals. In the United Kingdom the term is used specifically to describe the networks that have been licensed to use frequencies near 1.8 GHz.

**Point-to-point links**
Fixed links (see above) generally using highly directional antenna at both ends of the link.

**Private Mobile Radio (PMR)**
A private radio service installed and operated by businesses and public sector organisations to provide mobile communications for their own workforces. A base station is installed by each organisation on a suitable site providing local coverage, and used to send or receive short messages concerning the business of the organisation to, from or between, mobile units.

**Propagation**
The transmission of radio waves and the effect of the environment (terrain, climate, season etc) throughout their paths.

**Protection ratio**
The ratio of the strength of the wanted signal to that of the unwanted signal at the input to a radio receiver necessary to ensure that the effect of the unwanted signal (interference) is acceptable.

**Service providers**

a Public or private organisations providing radiocommunication services; or

b the intermediary between the network operator and the subscriber to the service (responsible for the direct commercial interface).

**Single side band transmission**
A technique for making amplitude modulated transmissions more spectrum efficient by suppressing the carrier and filtering one of the sidebands. With single side band transmissions, the radio bandwidth is the same as that of the basic information signal being transmitted.

**Spectrum management organisation**
An organisation which undertakes administrative and technical tasks of management of part of the radio spectrum, usually limited to the identification of suitable assignments, the keeping of records, the calculation of interference risks etc. but may include distribution of licences.

**Spread spectrum**
A technique in which the radio frequency signal is spread over a large range of frequencies in order to minimise its interference effect or its immunity to interference.

**Telepoint service**
A short range land mobile radio telephone service in which cordless telephones are used to communicate via the public telephone switched network.

**Trunked radio**
A mobile radio system in which a group of users share or pool a number of radio channels rather than each user or user group being assigned a specific channel.